



THE UNIVERSITY *of* EDINBURGH

This thesis has been submitted in fulfilment of the requirements for a postgraduate degree (e. g. PhD, MPhil, DClinPsychol) at the University of Edinburgh. Please note the following terms and conditions of use:

- This work is protected by copyright and other intellectual property rights, which are retained by the thesis author, unless otherwise stated.
- A copy can be downloaded for personal non-commercial research or study, without prior permission or charge.
- This thesis cannot be reproduced or quoted extensively from without first obtaining permission in writing from the author.
- The content must not be changed in any way or sold commercially in any format or medium without the formal permission of the author.
- When referring to this work, full bibliographic details including the author, title, awarding institution and date of the thesis must be given.

From the Adriatic to the Alps:
An Examination of Inland Trade in Northern
Italy Between the First Century BC and Fifth
Century AD

Volume I. Text and Bibliography

The University of Edinburgh



James R. Page

March 2022

Declaration

I declare that this thesis has been composed solely by myself that it has not been submitted, whole or in part, to any previous application for a degree. Except where stated otherwise by reference or acknowledgement, the work is entirely my own.

Signed:
James R. Page

Edinburgh,
14/03/2022

Abstract

Within the Italian peninsula, Northern Italy has previously been maligned as a marginal and unimportant inland region during the Roman era. Inland areas are assumed to have been difficult to access, with long-distance trade dropping off as distance from the coast increased. Although the presence of a navigable river might extend the reach of imports, prevailing orthodoxies continue to suggest areas furthest away from the coast had less access to overseas goods. Long-distance trade between coastal regions has been the subject of intensive study by Roman archaeologists for the past thirty years, but the complex dynamics that governed inland trade have not seen the same level of interest. Within this thesis, Northern Italy serves as a case study to explore the role transport cost and consumer choice played in the distribution of local and imported goods throughout inland regions during the Roman period, moving beyond simple models of marginality and isolation.

The thesis uses a combination of route network modelling and quantitative statistical analysis to study patterns of inland trade between the first century BC to the fifth century AD. Two network models, one mapping the cost and time of transporting ‘standard’ cargoes, the other mapping the cost and time of transporting ‘heavy’ cargoes, are examined. Containing over 136 nodes, they enable a significantly more detailed analysis of Northern Italy’s transport network than previous modelling. The results of the network analysis are compared against the geographical and chronological distribution of material data from 37 urban sites across the region. Three material datasets of amphorae, red-slipped finewares, and decorative stone are statistically analysed using a combination of hierarchical clustering, based on assemblage provenance, and diversity indices (Simpson’s Index and the Morisita-Horn Overlap Coefficient), utilising the individual vessels and lithotypes present within the datasets.

The results of the analysis show that inland trade in the Roman period was far more complex than a simple regression of imports as distance from the coast increased. Clear zones of consumption across Northern Italy are seen in the distribution of the material data, closely linked to transport costs. The Po river network is shown to have been crucial in facilitating long-distance trade from

the coast to inland regions, but the results also reveal that the significance of trans-mountain trade in supplying parts of Northern Italy with staple goods has been underestimated. Areas furthest inland are often shown to have had the greatest diversity in the provenance and types of material in their assemblages, as opposed to coastal areas, which demonstrate more limited provenances and greater uniformity. The results highlight the complex array of factors governing inland trade, alongside the interplay between cost and choice in the decisions made by consumers. Far from being a disconnected and isolated inland region, the Po valley and Northern Italy more generally is shown to have been connected to wider Eastern and Western Mediterranean markets and networks of information.

Lay Summary

Within the Italian peninsula, Northern Italy has previously been maligned as a marginal and unimportant inland region during the Roman era. Inland areas are assumed to have been difficult to access, with long-distance trade dropping off as distance from the coast increased. Long-distance trade between coastal regions has been the subject of intensive study by Roman archaeologists for the past thirty years, but the complex dynamics that governed inland trade have not seen the same level of interest. Within this thesis, Northern Italy serves as a case study to explore the role transport cost and consumer choice played in the distribution of local and imported goods throughout inland regions, moving beyond simple models of marginality and isolation. The results of the analysis show clear zones of consumption across Northern Italy closely linked to transport costs. The Po river network is shown to have been crucial in facilitating long-distance trade from the coast to inland regions, but the results also demonstrate that the significance of trans-mountain trade in supplying parts of Northern Italy with staple goods has been underestimated. The results highlight the complex array of factors governing inland trade and the interplay between cost and choice in the decisions made by consumers. Far from being a disconnected and isolated inland region, the Po valley and Northern Italy more generally is shown to have been connected to wider Eastern and Western Mediterranean markets and networks of information.

Acknowledgements

It goes without saying that this PhD would not have been possible without a great deal of support from a wide range of people and sources. Degrees are expensive things, and I am grateful to the School of History, Classics, and Archaeology Doctoral Scholarship for funding my PhD, along with the Baldwin Brown Traveling Scholarship and Research Student Support Fund for financing other research expenses. I also wish to thank the University of Edinburgh for granting a three-month extension to my funding in the face of difficulties imposed by the Covid-19 pandemic.

Of those who helped shape this thesis, I would first and foremost like to thank my primary supervisor, Ben Russell. Thank you for your encouragement, patience, and the innumerable hours of feedback and support you gave throughout the PhD. You have always pushed me to think and apply myself in new ways, and I would not be the researcher I am today without your guidance. Most of all, thank you for putting up with me through not one, not two, but three degrees. I promise to finally leave you in peace after this. Next, thank you to my evolving team of secondary supervisors, Xavier Rubio-Campillo, Andrew Dufton, and Louise Blanke, each of whom brought invaluable new perspectives to the project. Special thanks must go to Xavier, whose help was vital in developing the methodology used in the quantitative analysis and patience with QGIS and RStudio knew no bounds.

Outside of the supervision team, I wish to thank Tyler Franconi, for reading and commenting on sections of this work, and to Lucia Michelin for being the saviour of all GIS, LaTeX, and R related problems. I would also like to thank Candace Rice, whose mentorship and supervision during my undergraduate and Master's degrees couldn't have given a better foundation for pursuing the PhD. Words can't express my gratitude for all your help, advice, support, and friendship over the years.

Beyond the academic side of things, I am grateful to all the friends who helped support me along the way and made the PhD more bearable during the toughest times. I would like to thank the 12 o'clock lunch group of Sam Ellis, Dot Longely-Cook, Ambra Ghiringhelli, Rory Nutter, Madison Rolls, and Tad

Thorp in the McMillan Room for their friendship and shared morosity during our time in the HCA. In particular, I wish to thank Rory Nutter for always being available for an afternoon coffee at Checkpoint, and his ability to allay any worries or fears I had about the PhD. We'll make it back to Italy someday. Outside of the university, I would like to thank Sophie Cronshaw, Victoria Francois, Zofia Guertin, Charlotte Keeys, Briana King, Mikey Kotts, Carolina Krödel, Shaun Massie, Katharine May, Shannon McAllister, Kevin Morrow, Will Moss, and Blair Wilson for their friendship and support, alongside their (sometimes not so) gentle reminders that there was a world outside of the PhD. I'm not sure I would have finished without you. I am also forever indebted to Alice Latchford, for her incredible proofreading, constant friendship, and for persuading me to stick with it all during the darkest days of the Covid-19 pandemic.

Finally, none of this would have been possible without my parents, Philip and Carole Page. Thank you for always encouraging me to pursue my interests, your sage advice, unwavering support, and all the love you have given me over the years. This is for you.

Contents

Abstract	5
Lay Summary	7
Acknowledgements	9
Abbreviations	17
A Note on Figures and Place Names	19
List of Figures	21
List of Tables	37
1 Introduction	41
1.1 Regional Economies, Trade, and Rivers	44
1.2 Northern Italy and the Po Valley	49
1.3 Methods and Approaches	54
1.3.1 Network Analysis	55
1.3.2 Quantitative Material Analysis	56
1.4 Structure	58
Part 1: Landscape and the Transport Network	60
2 Landscape and Hydrology	63
2.1 Topography and Climate	65
2.1.1 The Alps	65
2.1.2 The Apennines	66
2.1.3 The Po-Veneto Plain	66
2.2 The Hydrology of the Po-Veneto River Network	68
2.2.1 The Evolution of the Po River Network	71
2.2.2 Ancient Writers on the Po River Network	73
2.2.3 The Paleohydrological and Paleoclimatological Evidence	76

2.3	The Human Landscape	79
2.3.1	Agriculture, Centuriation, and Land Reclamation	80
2.3.2	Responding to Hydrological Risk	82
2.4	Conclusions	84
3	Transport and Infrastructure	87
3.1	The Water Network	89
3.1.1	The Development of the Fluvial Transport Network	92
3.1.2	The Para-Littoral Canals	94
3.1.3	Moving on the Waterways	97
3.1.4	Vessels and Cargoes	100
3.1.5	Ports and Harbours	106
3.2	The Road Network	110
3.2.1	Development of the Road Network	111
3.2.2	Infrastructure	115
3.3	Conclusions	120
4	Modelling the Transport Network	121
4.1	Networks	123
4.1.1	Networks in Roman Archaeology	123
4.1.2	Network Limitations	125
4.2	Factors and Variables	126
4.3	Missing Variables	130
4.3.1	Canals	131
4.3.2	Transshipment	133
4.3.3	Gradient	137
4.4	Methodology	139
4.4.1	Digitising the Ancient Transport Network	139
4.4.2	Creating the Network Dataset	141
4.5	Results: Cost	142
4.5.1	The Adriatic Coast	142
4.5.2	The Ligurian Coast	143
4.5.3	Inland Sites	144
4.5.4	Heavy Cargoes	145
4.6	Results: Time	146
4.6.1	The Adriatic Coast	146
4.6.2	The Ligurian Coast	147
4.6.3	Inland Sites	148
4.6.4	Heavy Cargoes	149

4.7	Discussion	149
4.8	Conclusions	153
Part 2: The Material Analysis		154
5	Methodology	157
5.1	Selecting the Data	159
5.1.1	Ceramic Assemblages	161
5.1.2	Decorative Stone Assemblages	163
5.2	Preparing the Data	166
5.2.1	Amphorae	166
5.2.2	Finewares	169
5.2.3	Decorative Stone	172
5.3	The Quantitative Analysis	173
5.4	Conclusions	175
6	Amphorae	177
6.1	Data and Deposits	178
6.2	Analysis	180
6.3	Results	180
6.3.1	The Late Republic	182
6.3.2	The First-Second Centuries AD	185
6.3.3	The Third-Fifth Centuries AD	191
6.4	Discussion: The Late Republic	194
6.5	Discussion: The First-Second Centuries AD	195
6.5.1	Adriatic Production and Regional Markets	195
6.5.2	Changing Zones of Consumption	197
6.5.3	The Question of Choice	200
6.6	Discussion: The Third-Fifth Centuries AD	201
6.7	Conclusions	204
7	Finewares	207
7.1	Fineware Types	209
7.1.1	Northern Italic Terra Sigillata	209
7.1.2	Middle Adriatic Terra Sigillata	211
7.2	Analysis	212
7.3	Results: Fineware by Period	212
7.3.1	The First-Second Centuries AD	212
7.3.2	The Third-Fifth Centuries AD	217

7.4	Results: Finewares by Century	219
7.4.1	The Augustan Period	219
7.4.2	The First Century AD	221
7.4.3	The Second Century AD	221
7.4.4	The Third Century AD	222
7.4.5	The Fourth Century AD	223
7.4.6	The Fifth Century AD	224
7.5	Discussion: The First-Second Centuries AD	224
7.5.1	Northern Italic Terra Sigillata and Short-Distance Trade	225
7.5.2	Central Italic Sigillata: Desirability and Choice	226
7.5.3	Gallic Terra Sigillata and Trans-Alpine Trade	228
7.5.4	Other Provenances	231
7.6	Discussion: The Third-Fifth Centuries AD	231
7.7	Conclusions	234
8	Decorative Stone	237
8.1	The Roman Stone Trade	238
8.2	Analysis	241
8.3	Results	242
8.4	Discussion	245
8.4.1	The Eastern Valley and the Dominance of Imports from Asia Minor	245
8.4.2	Alpine Stones in the North-West	247
8.4.3	Central Italian Lithotypes: A Limited Distribution	248
8.4.4	Beyond Veneer: Comparative Data from Other Stone and Marble Datasets.	251
8.5	Conclusions	253
	Part 3: Conclusions	254
9	River Valleys, Trade, and Inland Economies	257
9.1	Zones of Consumption	258
9.1.1	The Coastal Plain and Central Valley	259
9.1.2	The North-West Po Valley and Alpine Valleys	262
9.1.3	The West and South-Western Po Valley	266
9.2	Inland Trade: Costs and other factors	270
9.2.1	Geography: Rivers and Mountains	270
9.2.2	Theory vs. Reality: Complicating Costs	274
9.2.3	Amphora, Finewares, and Stone: Contrasting Patterns	276

9.2.4	Chronological Variations	278
9.3	The Question of Exports	280
9.4	A Disconnected and Isolated Region?	282
9.5	Conclusions	287
	Bibliography	291

Abbreviations

AAR - American Academy in Rome

AE – *L'Année épigraphique*

CIL – *Corpus Inscriptionum Latinarum*

DAI - Deutsches Archäologisches Institut Rom

ILS – *Inscriptiones Latinae Selectae*

LRA - Late Roman Amphora

P. Lond. – London Papyri

P. Oxy. – Oxyrhynchus Papyri

A Note on Figures and Place Names

All figures can be found within Volume II of the thesis. Unlicensed figures are also available in higher definition at the following web address:

https://figshare.com/projects/From_the_Adriatic_to_the_Alps_An_Examination_of_Inland_Trade_in_Northern_Italy_Between_the_First_Century_BC_and_Fifth_Century_AD/133209

For locations mentioned within the text, the best-known name is used, whether modern or ancient. For example, Aosta is used instead of Augusta Praetoria, while Altinum is used instead of Altino.

List of Figures

- 1.1 Map of the area under study within this thesis.
- 2.1 The locations of sites discussed within Chapter 2.
- 2.2 The locations of the main mountain ranges and groups of hills within Northern Italy.
- 2.3 The spread of alluvial fans between the Alps, Apennines, and the Po-Veneto plain (Fontana et al. (2014), Fig. 3).
- 2.4 The major rivers of the Po-Veneto plain.
- 2.5 Graph of average discharge by month for the Po (Montanari (2012), Fig. 4).
- 2.6 The braided channel of the Tagliamento river. <https://www.reformrivers.eu/system/files/Tagliamento.JPG> (Accessed 23/01/2022).
- 2.7 Map of the evolution of the western Adriatic coast and Po delta over time (Stefani (2017), Fig. 16.2).
- 2.8 Map showing the possible path of the rivers in the Po delta during the Roman period. <http://www.museodeltaantico.com/en/sezion e/a-territory-without-a-city/> (Accessed 13/05/19).
- 2.9 Centuriation schemes along the path of the via Aemilia (Muzzoli (2010), Fig. 6).
- 2.10 Trachyte lined embankments from the Roman period near Este (Balista and Bianchin Citton (1987), Fig. 6).
- 2.11 Cross-section of the Arzeron della Regina (Page (2021), Fig. 5).
- 2.12 Map of the route of the Arzeron della Regina, running parallel to the River Brenta (Rosada and Bonetto (1995), Fig. 2).
- 3.1 The locations of sites discussed within Chapter 3.
- 3.2 Map of navigable rivers within Northern Italy.
- 3.3 Map showing the proposed route of the para-littoral canals.
- 3.4 The Peutinger Table showing the route of the para-littoral canals along the Adriatic coast between Ravenna and Altinum. <http://peutinger.atlantides.org/map-a/> (Accessed 12/05/19).
- 3.5 Map of the *Fossa Augusta* entering Ravenna (Manzelli (2000), Fig. 149). The path of the canal is marked by n. 136.

- 3.6 An excavated section of the *Fossa Augusta* embankment near Ravenna (Roncuzzi and Veggi (1968), 195).
- 3.7 Excavated foundation for a proposed lighthouse tower along the route of the *Fossa Augusta*, near the mouth of the River Agosta. https://www.estense.com/wp-content/uploads/2015/11/Scavo-Baro-Zavelea_2015.jpg (Accessed 28/06/2021).
- 3.8 The Neumagen Wine Ship, third century AD. Rheinisches Landesmuseum, Trier. <https://www.worldhistory.org/uploads/images/9651.jpg?v=1612112407> (Accessed 04/04/20).
- 3.9 Relief of a wine laden vessel being towed from the late first-early second century AD. Musée lapidaire d'Avignon. https://i2.wp.com/followinghadrian.com/wp-content/uploads/2020/08/50155048357_f778860039_4k-1.jpg?ssl=1 (Accessed 28/06/21).
- 3.10 Map of wreck locations within Northern Italy.
- 3.11 Plan of the villa at Corte Cavanella. The Corte Cavanella 1 Wreck is visible in the top right of the image (Sanesi et al. (1985), Fig. 1a).
- 3.12 The Corte Cavanella 2 Wreck in situ (Sanesi et al. (1986), Fig. 4).
- 3.13 Diagram of the sewn plank construction method commonly seen in the Upper Adriatic (Willis and Capulli (2018), Fig. 4).
- 3.14 Diagram of the Comacchio Wreck's hull. https://www2.rgzm.de/scripts/dbWeb/dbwebc.dll/SingleString_Full_Image?linkxresults/obj/Part%5FStringsearch/col/NR/dat/2196 (Accessed 04/04/20).
- 3.15 The Parco Teodorico Wreck in situ. <https://www.marine-antique.net/local/cache-vignettes/L890xH600/nave-ravenna-theodoric-01-8ed8a.jpg> (Accessed 04/04/20).
- 3.16 The Monfalcone Wreck in situ. <https://www2.rgzm.de/Navis/Ships/Ship057/Image/057F0032.jpg> (Accessed 04/04/20).
- 3.17 The Zwammerdam 2 in situ. https://www.universiteitleiden.nl/binaries/large/content/gallery/ul2/images-in-text/imange-in-text_nieuws-nov-2016_boot-2-zwammerdam.jpg (Accessed 04/04/20).
- 3.18 The Arles-Rhône 3 (first century AD) in the Musée de l'Arles antique. http://www.arles-antique.cg13.fr/mdaa.cg13/ar3/_imgs/espace_presse/PresentationChalandAR3_remibenali.jpg (Accessed 04/04/20).
- 3.19 Diagram of the Stella 1 Wreck (Castro and Capulli (2016), Fig. 3).
- 3.20 Diagram and orthophoto of the Santa Maria in Padovetere (Beltrame and Costa (2016), Fig. 3).
- 3.21 Site plan of the Bacchiglione Wreck. Note the gap between the

- two sets of stone elements where a perishable or salvageable cargo may have been placed (Previato and Zara (2014), Fig. 2).
- 3.22 Plan of the *horreum* discovered along the banks of the Po in Turin (Barrico and Subbrizio (2007), Tav. XXIX).
 - 3.23 Map of ports remains in Northern Italy.
 - 3.24 Diagram of the Roman quay discovered at Ivrea (Finocchi (1980), Tav. XXVIIb).
 - 3.25 Photograph of one of the quay walls at Tortona (Crosetto (2013a), Fig. 3).
 - 3.26 Plan of the canal channel at Vercelli (Panero (2013), Fig. 1).
 - 3.27 Section of quayside in Milan between the via Baracchini and the via Paolo da Cannobio (Caporusso (1990), Fig. 241).
 - 3.28 Photograph of the quayside at Brescia (Cavaliere Manasse (1990), Tav. VII).
 - 3.29 Photograph of the quay at Padua (Uggeri (1987), Tav. IVB).
 - 3.30 Diagram of the quay at Oderzo with the amphora reclamation deposit behind (Cipriano and Sandrini (2001), Fig. 3).
 - 3.31 Reconstruction of the port and waterwheel at Oderzo (Cipriano and Sandrini (2001), Fig. 4).
 - 3.32 Plan and section of the Roman jetties at Pardenghe (Uggeri (1990), Fig. 4).
 - 3.33 Map of the road network in Northern Italy at the end of the first century AD.
 - 3.34 Map of infrastructure in Northern Italy constructed using Eugeanean Trachyte (Previato (2018), Fig. 7).
 - 3.35 Photograph of wooden piling to support the foundations of the on the path of the via Annia near Roncade, Treviso (Busana (2008), Fig. 6).
 - 3.36 Reconstruction of the via Annia embankment near Ca' Tron, Veneto (Busana (2008), Fig. 5).
 - 3.37 The Roman cutting at Donnas that allowed the road to run above the level of the Dora Baltea, Valle d'Aosta. <https://www.valledaosta-guidaturistica.it/wp-content/uploads/2015/12/strada-donnas.jpg> (Accessed 08/04/20).
 - 3.38 Diagram of the retaining wall at Villeneuve, Valle d'Aosta (Mollo Mezzana (1992), Fig. 6).
 - 3.39 The Roman embankment at Runaz, Valle d'Aosta. <http://www.viadellegalie.vda.it/poi/show/12-avise-runaz> (Accessed 08/04/20).
 - 3.40 The Roman bridge and embankment at Saint Vincent, Valle d'Aosta.

- https://upload.wikimedia.org/wikipedia/commons/3/3f/Ponte_romano_%28Saint-Vincent%29_abc3.JPG (Accessed 08/04/20).
- 3.41 Stela of a *nauta* from Augusta Bagiennorum, often interpreted as representing a ferryman. http://db.edcs.eu/epigr/bilder.php?bild=InscrIt_09_01_00035.jpg;pp&nr=1 (Accessed 12/03/20).
- 3.42 Diagram of the Ponte San Lorenzo, Padua (Cera (1996), Fig. 4).
- 3.43 Diagram of the Roman bridge at Julia Concordia, demonstrating the shallow arch (Cera (1996), Fig. 9).
- 3.44 Photograph showing the narrow arches of the Ponte delle Barche, Vicenza. https://upload.wikimedia.org/wikipedia/commons/2/23/Pt_Barche-1.jpg (Accessed 08/04/20).
- 4.1 Network connectivity map of Roman Italy from Carreras and De Soto (2013), Fig. 12.
- 4.2 Map showing the cost of transport from Rome in the summer generated by ORBIS (Scheidel (2014), Fig. 6).
- 4.3 The locations of sites discussed within Chapter 4.
- 4.4 Map showing the extent of the transport network in the Po-Veneto region included in the Stanford ORBIS model (<https://orbis.stanford.edu/> (Accessed 25/03/2021)).
- 4.5 Graph showing the relation between cost and the tangent of a slope. (Bell, Wilson, and Wickham (2002), Fig. 6).
- 4.6 Map showing the extent of the network model and different vector layers within it.
- 4.7 Map showing the location of nodes within the network.
- 4.8 Map showing the location of junctions between maritime and terrestrial transport.
- 4.9 Map showing the location of junctions between maritime and fluvial transport.
- 4.10 Map showing the location of junctions between maritime and canal transport.
- 4.11 Map showing the location of junctions between fluvial and terrestrial transport.
- 4.12 Map showing the location of junctions between fluvial and canal transport.
- 4.13 Map showing the location of junctions between canal and terrestrial transport.
- 4.14 Image of the attribute table for the river vectors shapefile, detailing the different edge weights.

- 4.15 Map showing the incremental cost of transport from the Adriatic seaports.
- 4.16 Map showing the incremental cost of transport from the Ligurian seaports.
- 4.17 Map showing the incremental cost of transport from Aosta.
- 4.18 Map showing the incremental cost of transport from Cremona.
- 4.19 Map showing the incremental cost of transport from Milan.
- 4.20 Map showing the incremental cost of transport from Turin.
- 4.21 Map showing the incremental cost of the transport of heavy cargoes from the Adriatic seaports.
- 4.22 Map showing the incremental cost of the transport of heavy cargoes from the Ligurian seaports.
- 4.23 Map showing the incremental time of transport from the Adriatic seaports.
- 4.24 Map showing the incremental time of transport from the Ligurian seaports.
- 4.25 Map showing the incremental time of transport from Aosta.
- 4.26 Map showing the incremental time of transport from Cremona.
- 4.27 Map showing the incremental time of transport from Milan.
- 4.28 Map showing the incremental time of transport from Turin.
- 4.29 Map showing the incremental time of transporting heavy cargoes from the Adriatic seaports.
- 4.30 Map showing the incremental time of transporting heavy cargoes from the Ligurian seaports.
- 4.31 Map showing the incremental cost of transport from both the Adriatic and Ligurian seaports.

- 5.1 The locations of sites discussed within Chapter 5.
- 5.2 The locations of the assemblages used in the material analysis.
- 5.3 The locations of known Dressel 6A and 6B kilns in the Adriatic area (Cipriano and Mazzocchin (2019), Fig. 2).

- 6.1 The locations of sites discussed within Chapter 6.
- 6.2 An amphora reclamation deposit found during the excavations at Parco Novi Sad, Modena. http://www.archeobologna.beniculturali.it/modena/novisad/scavi_2009-2010.htm (Accessed 17/02/2022).
- 6.3 Locations of the amphora assemblages analysed in Chapter 6.
- 6.4 Number of amphora sherds by period.
- 6.5 Provenance of amphorae during the Late Republic.
- 6.6 Provenance of amphorae by site during the Late Republic.

- 6.7 Total percentage of each vessel form with an Adriatic provenance from the Late Republic dataset.
- 6.8 Total percentage of each vessel form with an Eastern provenance from the Late Republic dataset.
- 6.9 Total percentage of each vessel form with an Iberian provenance from the Late Republic dataset.
- 6.10 Total percentage of each vessel form with a North African provenance from the Late Republic dataset.
- 6.11 Total percentage of each vessel form with a Tyrrhenian provenance from the Late Republic dataset.
- 6.12 Drawing of the Lamboglia 2 amphora form. https://archaeologydataservice.ac.uk/archives/view/amphora_ahrb_2005/zoom.cfm?id=229&img=DR136&CFID=a92fc974-9c32-4adf-8031-ffe32bb15674&CFTOKEN=0 (Accessed 17/01/2022).
- 6.13 Map of known Lamboglia 2 kiln sites (Carre et al. (2014), Fig. 1).
- 6.14 Drawing of the Brindisian amphora form. https://archaeologydataservice.ac.uk/archives/view/amphora_ahrb_2005/zoom.cfm?id=51&img=DR134&CFID=a92fc974-9c32-4adf-8031-ffe32bb15674&CFTOKEN=0 (Accessed 17/01/2022).
- 6.15 Drawing of the Greco-Italic amphora form. https://archaeologydataservice.ac.uk/archives/view/amphora_ahrb_2005/zoom.cfm?id=141&img=DR118&CFID=a92fc974-9c32-4adf-8031-ffe32bb15674&CFTOKEN=0 (Accessed 17/01/2022).
- 6.16 Drawing of the Ovoidali Adriatiche amphora form (Carre and Pesavento Mattioli (2003), Fig. 1).
- 6.17 Drawing of the Dressel 1 amphora form. https://archaeologydataservice.ac.uk/archives/view/amphora_ahrb_2005/zoom.cfm?id=324&img=DR104&CFID=a92fc974-9c32-4adf-8031-ffe32bb15674&CFTOKEN=0 (Accessed 17/01/2022).
- 6.18 Total amphora contents by sherd count for the Late Republic.
- 6.19 Total amphora contents by volume for the Late Republic.
- 6.20 Hierarchical clustering based on amphora provenance during the Late Republic.
- 6.21 Geographic distribution of the cluster in Figure 6.20.
- 6.22 Hierarchical clustering based on amphora provenance during the Late Republic, including the Adriatic ports.
- 6.23 Hierarchical clustering based on amphora provenance during the Late Republic, including the Ligurian ports.
- 6.24 Simpson's Index scores for amphora assemblage diversity during

- the Late Republic.
- 6.25 Amphora assemblage similarity between sites measured using the Morisita-Horn Overlap Coefficient during the Late Republic.
 - 6.26 Stamped amphora forms during the Late Republic.
 - 6.27 Stamp assemblage similarity between sites during the Late Republic, measured using the Morisita-Horn Overlap Coefficient.
 - 6.28 Provenance of amphorae during the first-second centuries AD.
 - 6.29 Provenance of amphorae by site during the first-second centuries AD.
 - 6.30 Total percentage of each vessel form with an Adriatic provenance from the first-second centuries AD dataset.
 - 6.31 Total percentage of each vessel form with an Eastern provenance from the first-second centuries AD dataset.
 - 6.32 Total percentage of each vessel form with a Gallic provenance from the first-second centuries AD dataset.
 - 6.33 Total percentage of each vessel form with an Iberian provenance from the first-second centuries AD dataset.
 - 6.34 Total percentage of each vessel form with a North African provenance from the first-second centuries AD dataset.
 - 6.35 Total percentage of each vessel form with a Tyrrhenian provenance from the first-second centuries AD dataset.
 - 6.36 Total percentage of each vessel form with an Unknown provenance from the first-second centuries AD dataset.
 - 6.37 Drawing of the Dressel 6A amphora form. https://archaeologydataservice.ac.uk/archives/view/amphora_ahrb.2005/zoom.cfm?id=113&img=DR137&CFID=a92fc974-9c32-4adf-8031-ffe32bb15674&CFTOKEN=0 (Accessed 17/01/2022).
 - 6.38 Drawing of the Dressel 6B amphora form. https://archaeologydataservice.ac.uk/archives/view/amphora_ahrb.2005/zoom.cfm?id=114&img=DR138&CFID=a92fc974-9c32-4adf-8031-ffe32bb15674&CFTOKEN=0 (Accessed 17/01/2022).
 - 6.39 Drawing of the Flat-Bottomed Italic amphora form. https://archaeologydataservice.ac.uk/archives/view/amphora_ahrb.2005/zoom.cfm?id=130&img=DR177&CFID=a92fc974-9c32-4adf-8031-ffe32bb15674&CFTOKEN=0 (Accessed 17/01/2022).
 - 6.40 Drawing of the Anfora con Collo ad Imbuto form. https://archaeologydataservice.ac.uk/archives/view/amphora_ahrb.2005/zoom.cfm?id=69&img=DR268&CFID=a92fc974-9c32-4adf-8031-ffe32bb15674&CFTOKEN=0 (Accessed 17/01/2022).

- 6.41 Drawing of the Dressel 2-4 amphora form. https://archaeologydataservice.ac.uk/archives/view/amphora_ahrb_2005/zoom.cfm?id=102&img=DR188&CFID=a92fc974-9c32-4adf-8031-ffe32bb15674&CFTOKEN=0 (Accessed 17/01/2022).
- 6.42 Drawing of the Camulodunum 184 amphora form. https://archaeologydataservice.ac.uk/archives/view/amphora_ahrb_2005/zoom.cfm?id=74&img=DR123&CFID=a92fc974-9c32-4adf-8031-ffe32bb15674&CFTOKEN=0 (Accessed 17/01/2022).
- 6.43 Drawing of the Dressel 7 amphora form. https://archaeologydataservice.ac.uk/archives/view/amphora_ahrb_2005/zoom.cfm?id=115&img=DR448&CFID=a92fc974-9c32-4adf-8031-ffe32bb15674&CFTOKEN=0 (Accessed 17/01/2022).
- 6.44 Drawing of the Dressel 12 amphora form. https://archaeologydataservice.ac.uk/archives/view/amphora_ahrb_2005/zoom.cfm?id=67&img=DR291&CFID=a92fc974-9c32-4adf-8031-ffe32bb15674&CFTOKEN=0 (Accessed 17/01/2022).
- 6.45 Drawing of the Dressel 14 amphora form. https://archaeologydataservice.ac.uk/archives/view/amphora_ahrb_2005/zoom.cfm?id=68&img=DR101&CFID=a92fc974-9c32-4adf-8031-ffe32bb15674&CFTOKEN=0 (Accessed 17/01/2022).
- 6.46 Drawing of the Beltrán 2A amphora form. https://archaeologydataservice.ac.uk/archives/view/amphora_ahrb_2005/zoom.cfm?id=43&img=DR100&CFID=a92fc974-9c32-4adf-8031-ffe32bb15674&CFTOKEN=0 (Accessed 17/01/2022).
- 6.47 Drawing of the Dressel 20 amphora form. https://archaeologydataservice.ac.uk/archives/view/amphora_ahrb_2005/zoom.cfm?id=83&img=DR140&CFID=a92fc974-9c32-4adf-8031-ffe32bb15674&CFTOKEN=0 (Accessed 17/01/2022).
- 6.48 Drawing of the Richborough 527 amphora form. <http://potsherd.net/atlas/Ware/R527> (Accessed 17/01/2022).
- 6.49 Drawing of the Gauloise 2 amphora form. https://archaeologydataservice.ac.uk/archives/view/amphora_ahrb_2005/zoom.cfm?id=134&img=DR537&CFID=a92fc974-9c32-4adf-8031-ffe32bb15674&CFTOKEN=0 (Accessed 17/01/2022).
- 6.50 Drawing of the Gauloise 4 amphora form. https://archaeologydataservice.ac.uk/archives/view/amphora_ahrb_2005/zoom.cfm?id=136&img=DR542&CFID=a92fc974-9c32-4adf-8031-ffe32bb15674&CFTOKEN=0 (Accessed 17/01/2022).
- 6.51 Drawing of the Africana 1 amphora form. <https://archaeologydat>

- ataservice.ac.uk/archives/view/amphora_ahrb_2005/zoom.cfm?id=1&img=DR144&CFID=a92fc974-9c32-4adf-8031-ffe32bb15674&CFTOKEN=0 (Accessed 17/01/2022).
- 6.52 Total amphora contents by sherd count for the first-second centuries AD.
- 6.53 Total amphora contents by volume for the first-second centuries AD.
- 6.54 Hierarchical clustering based on amphora provenance during the first-second centuries AD.
- 6.55 Geographic distribution of the clusters in Figure 6.54.
- 6.56 Hierarchical clustering based on amphora provenance during the first-second centuries AD, including the Adriatic ports.
- 6.57 Hierarchical clustering based on amphora provenance during the first-second centuries AD, including the Ligurian ports.
- 6.58 Simpson's Index scores for amphora assemblage diversity during the first-second centuries AD.
- 6.59 Amphora assemblage similarity between sites measured using the Morisita-Horn Overlap Coefficient during the first-second centuries AD.
- 6.60 Stamped amphora forms during the first-second centuries AD.
- 6.61 Stamp assemblage similarity between sites during the first-second centuries AD, measured using the Morisita-Horn Overlap Coefficient.
- 6.62 Provenance of amphorae during the third-fifth centuries AD.
- 6.63 Provenance of amphorae by site during the third-fifth centuries AD.
- 6.64 Total percentage of each vessel form with an Eastern provenance from the third-fifth centuries AD dataset.
- 6.65 Total percentage of each vessel form with an Iberian provenance from the third-fifth centuries AD dataset.
- 6.66 Total percentage of each vessel form with a North African provenance from the third-fifth centuries AD dataset.
- 6.67 Total percentage of each vessel form with a Tyrrhenian provenance from the third-fifth centuries AD dataset.
- 6.68 Total percentage of each vessel form with an Unknown provenance from the third-fifth centuries AD dataset.
- 6.69 Drawing of the Almagro 54 amphora form. https://archaeologydataservice.ac.uk/archives/view/amphora_ahrb_2005/zoom.cfm?id=16&img=DR161&CFID=a92fc974-9c32-4adf-8031-ffe32bb15

- 674&CFTOKEN=0 (Accessed 17/01/2022).
- 6.70 Drawing of the LRA 3 amphora form. https://archaeologydataservice.ac.uk/archives/view/amphora_ahrb_2005/zoom.cfm?id=240&img=DR129&CFID=a92fc974-9c32-4adf-8031-ffe32bb15674&CFTOKEN=0 (Accessed 17/01/2022).
- 6.71 Drawing of the Spatheion 1 amphora form. https://archaeologydataservice.ac.uk/archives/view/amphora_ahrb_2005/zoom.cfm?id=289&img=DR131&CFID=a92fc974-9c32-4adf-8031-ffe32bb15674&CFTOKEN=0 (Accessed 17/01/2022).
- 6.72 Drawing of the Africana 3A amphora form. https://archaeologydataservice.ac.uk/archives/view/amphora_ahrb_2005/zoom.cfm?id=208&img=DR504&CFID=a92fc974-9c32-4adf-8031-ffe32bb15674&CFTOKEN=0 (Accessed 17/01/2022).
- 6.73 Drawing of the Africana 2A amphora form. https://archaeologydataservice.ac.uk/archives/view/amphora_ahrb_2005/zoom.cfm?id=3&img=DR605&CFID=a92fc974-9c32-4adf-8031-ffe32bb15674&CFTOKEN=0 (Accessed 17/01/2022).
- 6.74 Drawing of the Almagro 51A-B amphora form. https://archaeologydataservice.ac.uk/archives/view/amphora_ahrb_2005/zoom.cfm?id=13&img=DR39&CFID=a92fc974-9c32-4adf-8031-ffe32bb15674&CFTOKEN=0 (Accessed 17/01/2022).
- 6.75 Drawing of the Almagro 51C amphora form. https://archaeologydataservice.ac.uk/archives/view/amphora_ahrb_2005/zoom.cfm?id=15&img=DR271&CFID=a92fc974-9c32-4adf-8031-ffe32bb15674&CFTOKEN=0 (Accessed 17/01/2022).
- 6.76 Drawing of the Keay 52 amphora form. https://archaeologydataservice.ac.uk/archives/view/amphora_ahrb_2005/zoom.cfm?id=161&img=DR229&CFID=a92fc974-9c32-4adf-8031-ffe32bb15674&CFTOKEN=0 (Accessed 17/01/2022).
- 6.77 Total amphora contents by sherd count for the third-fifth centuries AD.
- 6.78 Total amphora contents by volume for the third-fifth centuries AD.
- 6.79 Hierarchical clustering based on amphora provenance during the third-fifth centuries AD.
- 6.80 Geographic distribution of the clusters in Figure 6.79.
- 6.81 Hierarchical clustering based on amphora provenance during the third-fifth centuries AD, including the Adriatic ports.
- 6.82 Simpson's Index scores for amphora assemblage diversity during the third-fifth centuries AD.

-
- 6.83 Amphora assemblage similarity between sites measured using the Morisita-Horn Overlap Coefficient during the third-fifth centuries AD.
 - 6.84 Distribution of the Lamboglia 2 amphora across the Roman world (van den Berg (2012), Fig. 9).
 - 6.85 Distribution of the Dressel 6A amphora across the Roman world (van den Berg (2012), Fig. 10).
 - 6.86 Distribution of the Dressel 6B amphora across the Roman world (van den Berg (2012), Fig. 8).
 - 6.87 A sarcophagus depicting a transaction of wine carried in a barrel, Ancona (Van Limbergen (2018), Fig. 6).

 - 7.1 The locations of sites discussed within Chapter 7.
 - 7.2 Distribution map of Northern Italic Terra Sigillata (Kenrick (2000), Fig. 2).
 - 7.3 Locations of the fineware assemblages analysed in this chapter.
 - 7.4 Number of finewares by period.
 - 7.5 Provenance of finewares during the first-second centuries AD.
 - 7.6 Provenance of finewares by site during the first-second centuries AD.
 - 7.7 Origin of Gallic sigillata in the first-second centuries AD.
 - 7.8 Hierarchical clustering based on fineware assemblage provenance during the first-second centuries AD.
 - 7.9 Geographic distribution of the clusters in Figure 7.8.
 - 7.10 Hierarchical clustering based on fineware assemblage provenance during the first-second centuries AD, including the Adriatic ports.
 - 7.11 Hierarchical clustering based on fineware assemblage provenance during the first-second centuries AD, including the port of Luna.
 - 7.12 Drawing of the Dragendorff 32/37 fineware form. https://upload.wikimedia.org/wikipedia/commons/9/97/Dragendorff_32.png (Accessed 24/01/2022).
 - 7.13 Drawing of the Dragendorff 37 fineware form. https://upload.wikimedia.org/wikipedia/commons/f/f0/Roman_pottery_samian_war_e_form_Dr_37.jpg (Accessed 24/01/2022).
 - 7.14 Simpson's Index scores for assemblage diversity during the first-second centuries AD.
 - 7.15 Assemblage similarity between sites measured using the Morisita-Horn Overlap Coefficient during the first-second centuries AD.
 - 7.16 Stamp assemblage similarity between sites measured using the

- Morisita-Horn Overlap Coefficient.
- 7.17 Geographic distribution of the clusters in Figure 7.16.
 - 7.18 Northern Italic stamp assemblage similarity between sites measured using the Morisita-Horn Overlap Coefficient.
 - 7.19 Geographic distribution of the clusters in Figure 7.18.
 - 7.20 Central Italic stamp assemblage similarity between sites measured using the Morisita-Horn Overlap Coefficient.
 - 7.21 Geographic distribution of the clusters in Figure 7.20.
 - 7.22 Arretine stamp assemblage similarity between sites measured using the Morisita-Horn Overlap Coefficient.
 - 7.23 Non-Arretine stamp assemblage similarity between sites measured using the Morisita-Horn Overlap Coefficient.
 - 7.24 Provenance of finewares during the third-fifth centuries AD.
 - 7.25 Provenance of finewares by site during the third-fifth centuries AD.
 - 7.26 Hierarchical clustering based on fineware assemblage provenance during the third-fifth centuries AD.
 - 7.27 Hierarchical clustering based on fineware assemblage provenance during the third-fifth centuries AD, including the Adriatic ports.
 - 7.28 ARS production types in the third-fifth centuries AD dataset.
 - 7.29 Drawing of the Hayes 50 fineware form (Hayes (1972), Fig. 12).
 - 7.30 Drawing of the Hayes 61B fineware form (Hayes (1972), Fig. 16).
 - 7.31 Drawing of the Brecciaroli Taborelli 19/22 fineware form (Biondani (2014), Fig. 10).
 - 7.32 Drawing of the Brecciaroli Taborelli 15/17 fineware form (Biondani (2014), Fig. 4).
 - 7.33 Simpson's Index scores for assemblage diversity during the third-fifth centuries AD.
 - 7.34 Assemblage similarity between sites measured using the Morisita-Horn Overlap Coefficient during the third-fifth centuries AD.
 - 7.35 Number of finewares by century.
 - 7.36 Provenance of finewares during the Augustan Period.
 - 7.37 Provenance of finewares by site during the Augustan Period.
 - 7.38 Hierarchical clustering based on fineware assemblage provenance during the Augustan Period.
 - 7.39 Hierarchical clustering based on fineware assemblage provenance during the Augustan Period, including the Adriatic ports.
 - 7.40 Hierarchical clustering based on fineware assemblage provenance during the Augustan Period, including the port of Luna.
 - 7.41 Simpson's Index scores for assemblage diversity during the Augustan

- tan Period.
- 7.42 Assemblage similarity between sites measured using the Morisita-Horn Overlap Coefficient during the Augustan Period.
 - 7.43 Provenance of finewares during the first century AD.
 - 7.44 Provenance of finewares by site during the first century AD.
 - 7.45 Hierarchical clustering based on fineware assemblage provenance during the first century AD.
 - 7.46 Hierarchical clustering based on fineware assemblage provenance during the first century AD, including the Adriatic ports.
 - 7.47 Hierarchical clustering based on fineware assemblage provenance during the first century AD, including the port of Luna.
 - 7.48 Simpson's Index scores for assemblage diversity during the first century AD.
 - 7.49 Assemblage similarity between sites measured using the Morisita-Horn Overlap Coefficient during the first century AD.
 - 7.50 Provenance of finewares during the second century AD.
 - 7.51 Provenance of finewares by site during the second century AD.
 - 7.52 Hierarchical clustering based on assemblage provenance during the second century AD.
 - 7.53 Hierarchical clustering based on assemblage provenance during the second century AD, including the Adriatic ports.
 - 7.54 Simpson's Index scores for assemblage diversity during the second century AD.
 - 7.55 Assemblage similarity between sites measured using the Morisita-Horn Overlap Coefficient during the second century AD.
 - 7.56 Provenance of finewares during the third century AD.
 - 7.57 Provenance of finewares by site during the third century AD.
 - 7.58 Hierarchical clustering based on assemblage provenance during the third century AD.
 - 7.59 Hierarchical clustering based on assemblage provenance during the third century AD, including the Adriatic ports.
 - 7.60 Simpson's Index scores for assemblage diversity during the third century AD.
 - 7.61 Assemblage similarity between sites measured using the Morisita-Horn Overlap Coefficient during the third century AD.
 - 7.62 Provenance of finewares during the fourth century AD.
 - 7.63 Provenance of finewares by site during the fourth century AD.
 - 7.64 Hierarchical clustering based on assemblage provenance during the fourth century AD.

- 7.65 Hierarchical clustering based on assemblage provenance during the fourth century AD, including the Adriatic ports.
- 7.66 Simpson's Index scores for assemblage diversity during the fourth century AD.
- 7.67 Assemblage similarity between sites measured using the Morisita-Horn Overlap Coefficient during the fourth century AD.
- 7.68 Provenance of finewares during the fifth century AD.
- 7.69 Provenance of finewares by site during the fifth century AD.
- 7.70 Simpson's Index scores for assemblage diversity during the fifth century AD.
- 7.71 Assemblage similarity between sites measured using the Morisita-Horn Overlap Coefficient during the fifth century AD.
- 7.72 Distribution maps for the stamps of the potters Sarius, Serius, and Terentius (Kenrick (2000), Figs. 3, 4, and 5).
- 7.73 Assemblage of a first-second centuries AD Aostan context (Redrawn from Gabucci (2017), Fig. 4.22).

- 8.1 The locations of sites discussed within Chapter 8.
- 8.2 Locations of known Roman quarries within Northern Italy.
- 8.3 Locations of the stone and marble assemblages analysed in Chapter 8.
- 8.4 Total percentage of each lithotype with an Alpine provenance from the stone dataset.
- 8.5 Total percentage of each lithotype quarried in Asia Minor from the stone dataset.
- 8.6 Total percentage of each lithotype with a Central Italian provenance from the stone dataset.
- 8.7 Total percentage of each lithotype with an Egyptian and North African provenance from the stone dataset.
- 8.8 Total percentage of each lithotype with a Gallic provenance from the stone dataset.
- 8.9 Total percentage of each lithotype with a Greek and Aegean provenance from the stone dataset.
- 8.10 Total percentage of each lithotype with an Unknown provenance from the stone dataset.
- 8.11 An example of Proconnesian marble. <http://www.oum.ox.ac.uk/corsi/stones/view/4> (Accessed 17/01/2022).
- 8.12 An example of *africano* marble. <https://www.oum.ox.ac.uk/corsi/stones/view/108> (Accessed 17/01/2022).

- 8.13 An example of *pavonazzetto* marble. <https://www.oum.ox.ac.uk/corsi/stones/view/123> (Accessed 17/01/2022).
- 8.14 An example of *cipollino* marble. <https://www.oum.ox.ac.uk/corsi/stones/view/90> (Accessed 17/01/2022).
- 8.15 An example of *breccia di Settebasi* marble. <https://www.oum.ox.ac.uk/corsi/stones/view/405> (Accessed 17/01/2022).
- 8.16 An example of *marmo Lesbio*. <https://www.oum.ox.ac.uk/corsi/stones/view/6> (Accessed 17/01/2022).
- 8.17 An example of *giallo antico* marble. <https://www.oum.ox.ac.uk/corsi/stones/view/22> (Accessed 17/01/2022).
- 8.18 An example of *bardiglio* marble. <https://www.oum.ox.ac.uk/corsi/stones/view/153> (Accessed 17/01/2022).
- 8.19 An example of white Luna marble. <https://www.oum.ox.ac.uk/corsi/stones/view/9> (Accessed 17/10/2022).
- 8.20 An example of *Verona rosso*. <http://www.oum.ox.ac.uk/corsi/img/stone/full/70.jpg> (Accessed 17/01/2022).
- 8.21 An example of *bianco e nero antico* marble. <https://www.oum.ox.ac.uk/corsi/stones/view/125> (Accessed 17/01/2022).
- 8.22 An example of *cipollino mandolato* marble. <https://www.oum.ox.ac.uk/corsi/stones/view/86> (Accessed 17/01/2022).
- 8.23 Provenances of stone and marble (including unprovenanced material).
- 8.24 Provenance of stone and marble (excluding unprovenanced material).
- 8.25 Provenance of stone and marble by site.
- 8.26 Provenance of stone and marble separated by colour.
- 8.27 Quantities of white, grey, and coloured marble at each site.
- 8.28 Hierarchical clustering based on stone and marble assemblage provenance.
- 8.29 Geographic distribution of the clusters in Figure 8.28.
- 8.30 Simpson's Index scores for assemblage diversity.
- 8.31 Assemblage similarity between sites measured using the Morisita-Horn Overlap Coefficient.
- 8.32 Distribution of Pentelic marble sarcophagi. Redrawn from Russell (2013), Fig. 5.6.
- 8.33 Distribution of Proconnesian marble sarcophagi. Redrawn from Russell (2013), Fig. 5.4.
- 8.34 Quantities of lithotypes used in the sarcophagi from Padua (Data from Gorrini and Robino (2015)).

- 9.1 The locations of sites discussed within Chapter 9.
- 9.2 Amphora cluster on the coastal plain and central valley in the Late Republic.
- 9.3 Amphora cluster on the coastal plain and central valley in the first-second centuries AD.
- 9.4 Fineware cluster on the coastal plain and central valley in the first-second centuries AD.
- 9.5 Decorative stone cluster on coastal plain and central valley.
- 9.6 Amphora cluster in the north-west of the Po valley and the Alpine valleys during the first-second centuries AD.
- 9.7 Fineware cluster in the north-west of the Po valley and the Alpine valleys during the first-second centuries AD.
- 9.8 Decorative stone cluster in the north-west of the Po valley and the Alpine valleys.
- 9.9 Amphora cluster in the west and south-west of the Po valley during the first-second centuries AD.
- 9.10 Decorative stone cluster in the west and south-west of the Po valley.
- 9.11 Heat maps of material distribution concentrated in the west and south-west of the Po valley.
- 9.12 Map of the Ebro basin, showing the proximity of its headwaters to another coastline. https://es.wikipedia.org/wiki/Tratado_del_Ebro###/media/Archivo:SpanienEbro.jpg (Accessed 23/11/2021).

List of Tables

2.1	Length, mean discharge, and basin size of the fourteen largest rivers in the Po basin (Po River Basin Authority (2006); Gumiero et al. (2009)).	69
2.2	Length, mean discharge, and basin size of other significant rivers within the Po-Veneto plain (Gumiero et al. (2009)).	71
3.1	Rivers with evidence for navigation during the Roman period in Northern Italy.	90
3.2	Mean discharge, length, and basin size of navigable rivers within the Roman Empire (After Franconi (2014), 35). *Euphrates data only available from Turkish border (80% total flow).	91
3.3	Inscriptions relating to <i>nautae</i> and <i>collegia nautarum</i> in Northern Italy.	93
3.4	Wrecks dating to the Roman period discovered in inland Northern Italy.	101
3.5	Port infrastructure dating to the Roman period discovered in Northern Italy.	107
3.6	Inscriptions relating to <i>iumentariorum</i> and <i>collegia iumentriorum</i> in Northern Italy.	114
4.1	Comparative estimates for the speed of transport in the Roman world.	127
4.2	Comparative estimates for the monetary cost of transport in the Roman world (kg = kilogram, km = kilometres, KM = <i>kastrensis modii</i> , RM = Roman miles, t = tonne).	128
4.3	Comparative ratios for the monetary cost of transport in the Roman world.	129
4.4	Comparative ratios for the monetary cost of transport across history. (After Russell (2013), 96).	129
4.5	The time in minutes to transfer different types of stone from a boat or cart (Adapted from Pegoretti (1869), 291).	135
4.6	Multipliers for the cost of transport dependent on slope percentage. 138	
4.7	The values for the monetary cost and speed of transport used	

within the network model.	142
5.1 Differences in the percentage of each amphora provenance from Brescia during the Late Republic when counted by Number of Sherds and MNI. Data from Bruno and Bocchio (1991).	161
5.2 Differences in the percentage of each amphora provenance from Brescia during the first-second centuries AD when counted by Number of Sherds and MNI. Data from Bruno and Bocchio (1991).	162
5.3 Differences in the percentage of each amphora provenance from Brescia during the third-fifth centuries AD when counted by Number of Sherds and MNI. Data from Bruno and Bocchio (1991).	162
5.4 Differences in the percentage of each stone provenance from Milan when counted by Number of Fragments and Volume. Data from Terracina (1991).	165
5.5 Differences in the percentage of each stone provenance from Aquileia when counted by Number of Fragments and Weight. Data from Previato and Mareso (2015).	165
5.6 The chronological periods selected for the amphora analysis.	168
5.7 The chronological periods selected for the fineware analysis.	170
6.1 Amphora assemblages analysed in Chapter 6.	181
7.1 Fineware assemblages analysed in Chapter 7.	213
7.2 Fineware assemblages separated by period.	220
8.1 Decorative stone assemblages analysed in Chapter 8.	241
9.1 Average transport costs in kg wheat for regular cargoes from the Adriatic and Ligurian coasts to sites in the coastal plain and central valley.	259
9.2 Average transport time in hours for regular cargoes from the Adriatic and Ligurian coasts to sites in the coastal plain and central valley.	260
9.3 Average transport costs in kg wheat for heavy cargoes from the Adriatic and Ligurian coasts to sites in the coastal plain and central valley.	261
9.4 Average transport time in hours for heavy cargoes from the Adriatic and Ligurian coasts to sites in the coastal plain and central valley.	262
9.5 Average transport costs in kg wheat for regular cargoes from the Adriatic and Ligurian coasts to sites in the north-west of the Po	

	valley and the Alpine valleys.	263
9.6	Average transport time in hours for regular cargoes from the Adriatic and Ligurian coasts to sites in the north-west of the Po valley and the Alpine valleys.	263
9.7	Average transport costs in kg wheat for heavy cargoes from the Adriatic and Ligurian coasts to sites in the north-west of the Po valley and the Alpine valleys.	264
9.8	Average transport time in hours for heavy cargoes from the Adriatic and Ligurian coasts to sites in the north-west of the Po valley and the Alpine valleys.	265
9.9	Average transport costs in kg wheat for regular cargoes from the Adriatic and Ligurian coasts to sites in the west and south-west of the Po valley.	266
9.10	Average transport time in hours for regular cargoes from the Adriatic and Ligurian coasts to sites in the west and south-west of the Po valley.	267
9.11	Average transport costs in kg wheat for heavy cargoes from the Adriatic and Ligurian coasts to sites in the west and south-west of the Po valley.	268
9.12	Average transport time in hours for heavy cargoes from the Adriatic and Ligurian coasts to sites in the west and south-west of the Po valley.	268

Chapter 1

Introduction

‘The eleventh region receives from the river the name of Transpadana; it is situated entirely inland, but the river carries to it on its bounteous channel the products of all the seas.’

Pliny the Elder, *Natural History* 3.123.¹

Despite being located hundreds of kilometres from the nearest seaport, the upper reaches of the Po valley were integrated into the wider Roman economy. Coastal regions, their prosperity, and integration, have been the subject of intensive study for the past thirty years, with shipping contracts and laws, vast port infrastructure, and hundreds of shipwrecks all attesting to their interconnectivity.² Yet many people in the Roman world did not live on the coast or in its immediate hinterland. While inland regions have not seen the same focused attention as coastal areas, they formed an important part of the Roman economy.³ The large production centres of Gallic sigillata at La Graufesenque and Lezoux, and African Red Slip (ARS) production sites between Kairouan and Sbeitla in Tunisia, were all located inland.⁴ Great quantities of *pavonazzetto* marble were extracted from Dokimion in central Anatolia and exported across the Roman world.⁵ Many less archaeologically visible products, such as perishable foodstuffs, livestock, timber, charcoal, and textiles, were also cultivated and extracted from inland areas.⁶ However, inland regions were not solely producers; they also consumed significant quantities of imported goods. The Rhenish Limes imported large sums of

¹ See bibliography for translations used.

² Brandon et al. (2014); Horden and Purcell (2000), in particular Chapters 4 and 5; Keay (2012); Morley (2007); Rice (2012), (2016); Robinson (2020); Tchernia (2011); (2016); Wilson (2009a); (2011); Wilson and Bowman (2018a); Wilson et al. (2012).

³ See Lavan (2015b), with accompanying bibliography.

⁴ Bonifay (2003); (2018); Lewit (2015); Mackensen and Schneider (2002).

⁵ Russell (2013), 170-75; (2018a), 140. See also the extraction of *giallo antico* at Chemtou in North Africa.

⁶ Diosono (2009), 258-76; Liu (2009), 29-31, 75-77; Lavan (2015b); Meiggs (1982); Roncaglia (2018), 89-95.

Baetican olive oil, Gallic wine, and sigillata.⁷ The Ebro valley consumed large quantities of wine produced along the Iberian coast, and the discovery of Iberian Dressel 20 and Dressel 2-4 amphorae at the Temple of Jupiter atop the summit of the Gran San Bernado Pass in the Alps demonstrates that imports could reach even the most remote parts of the Roman world.⁸

Although their distance from the sea did not exclude them from wider markets, inland regions faced additional obstacles to trade when compared with those on the coast. Maritime transport was the cheapest and fastest way of moving goods across the Roman world, but costs could rapidly increase as goods began to move inland.⁹ River transport, although more expensive than maritime, provided a cheaper alternative to overland travel.¹⁰ However, not every town was located on a navigable river, necessitating the completion of most journeys via overland transport.¹¹ The transshipment of cargo between maritime, fluvial, and overland transport also incurred additional costs.¹² The low cost of fluvial transport, when compared with overland travel, means river valleys have often played an important role in the development and functioning of inland trade, forming corridors of commerce and communication between the coast and the interior. Valley floors offer flat, fertile land for settlement and agriculture, with the rivers that flow through them presenting a source of water and, if they are navigable, a method of transportation. Even in the absence of a navigable river, a valley floor offers a level or gently sloping path inland, far easier, cheaper, and faster than traversing hills or mountains. The optimum conditions presented by river valleys would result in the development of several major productive landscapes in the Roman world. The Tiber valley produced food, oil, wine, and building materials for the city of Rome, resulting in an intensively cultivated landscape stretching from the city's hinterland to the river's torrential upper course.¹³ The Guadalquivir valley saw the creation of a landscape orientated around the production of olive oil for

⁷ Remesal-Rodríguez (1986); (1997); (2002). Although it might be argued that these imports were driven by state action to feed the frontier armies, Franconi (2014), 103-06, argues that there was also significant civilian demand for foreign goods which would eventually outstrip that of military. Indeed, civilian sites often show a greater diversity of foreign imports than military ones.

⁸ Beltrán Lloris (1987), 51–74; (2008), 271–318; Castillo (2014), 132-33; Paccolat et al. (2008), 149.

⁹ Russell (2018a), 140.

¹⁰ DeLaine (1992); De Soto (2019); Erim and Reynolds (1970); Scheidel (2014). Upstream river travel was more expensive than downstream, although still significantly cheaper than overland travel. While there is an established hierarchy in the cost of the transport in the Roman world, it is worth noting that many factors, such as weather, seasonality, terrain, and competition between traders would have affected prices (see Section 4.2).

¹¹ Laurence (2005) 138.

¹² Franconi (2014), 58; Russell (2013), 137.

¹³ Braconi (2009); DeLaine (1997); Diosono (2009); Graham (2002); McCallum (2004); Patterson et al. (2020); Vidal (2009).

export. This included both the olive oil itself and the transport apparatus in the form of Dressel 20 amphorae.¹⁴ The Nile valley formed one of the most important agricultural landscapes in the Roman world, with its produce responsible for supplying the *annona* in Rome.¹⁵ The river also formed an artery for the transport of stone from the Imperial quarries in the Eastern Desert and goods arriving at Red Sea ports to the Mediterranean coast.¹⁶

The economic impact of rivers has received increasing attention in Roman archaeology, however, not all rivers have been given equal consideration.¹⁷ In particular, the lack of investigation into the Po stands out. The Po, also known as the Padus or the Eridanus, is the largest river in Italy, host to dozens of tributaries, and was navigable as far as Turin in the Roman period. The wide, flat plain of its valley consisted of a highly urbanised landscape that included the great cities of Milan, Turin, and Bologna, and contained extensive agricultural wealth. Ancient writers are in unanimous agreement on the prosperity of the region. Polybius claimed the Po plain ‘surpassed in fertility any other in Europe’, while Tacitus called it the ‘richest district of Italy’.¹⁸ Yet, in spite of this, the Po valley has at times been written off in modern scholarship as ‘marginal’ or ‘isolated’, a border zone between Italy proper and the northern provinces that was economically insignificant.¹⁹ Although there have been moves to challenge the perception of isolation, this important region, the River Po, and its economy, remain severely neglected, especially in comparison to the attention that has been lavished on Italy’s other major river valley – that of the Tiber.²⁰ The Po valley’s archaeological evidence has been particularly under-utilised by prior regional studies, most of which have focused on literary and epigraphic data. Half a century of excavation across Northern Italy has unearthed substantial material

¹⁴ Ponsich (1974); (1979); Remesal-Rodríguez (1980); (1997); (1998).

¹⁵ Adams (2018); Erdkamp (2012).

¹⁶ Adams (2001); (2007); Peña (1989).

¹⁷ Campbell (2012)’s *Rivers and the Power of Ancient Rome* was the first book to synthesise much of the evidence on ancient rivers. While an essential study, its wide coverage led to a lack of depth in some areas. It has also been criticised for its predominantly western focus, reliance on literary evidence, and dismissal of the role that palaeoclimatological and palaeohydrological data can play in the analysis of ancient rivers. On these points, see Franconi (2013).

¹⁸ Polybius, 2.15; Tacitus, *Histories* 2.17.

¹⁹ Chilver (1941); Brunt (1971); Harris (2011a), (2011b); Haeussler (2013); Patterson (2006); Scheidel (2014).

²⁰ Broadhead (2000); Campbell (2012), 302-7; Roncaglia (2013); (2018). These studies take a more positive view of the region’s economy and connectivity during the Roman period. The Tiber valley has been the subject of intensive study for the past seventy years, beginning with the South Etruria Survey and most recently the Tiber Valley Project, which resulted in several major publications. See Coarelli and Patterson (2009); Patterson (2004); Patterson et al. (2020). It should be noted, however, that the majority of research has taken place in the lower and middle Tiber valley. The economy, population, and settlement in the upper valley is understood to a far lesser extent.

and structural remains from the Roman period, however, they have principally been studied by specialists, often at a local level.²¹ Only rarely has this body of evidence been applied to broader regional and economic questions.²²

A study of inland trade in Northern Italy, one that is grounded in the archaeological evidence, is long overdue. To this end, the thesis utilises a combination of network and quantitative material analyses to examine the mechanics of transport and trade within Northern Italy between the first century BC and the fifth century AD. The geographic scope of the project is the Po-Veneto region. This comprises the Po and Veneto plains and the surrounding watersheds of the rivers that flow through them, with the Alps, the Apennines, and the Adriatic Sea forming natural regional limits. The full extent of the study area is visible in Figure 1.1.²³ Below, a discussion of prior scholarship on the Roman economy, rivers, and Northern Italy provides a background to the subsequent work, while the methodologies applied in its analysis are outlined.

1.1 Regional Economies, Trade, and Rivers

The structure and nature of the Roman economy is the subject of a lively and ongoing debate, which has its origins in the early twentieth century. The history of this debate and the opposing minimalist and maximalist positions are well-known, and do not require revisiting in-depth here.²⁴ Throughout the course of the discussion, numerous models of economic activity have been theorised to aid

²¹ Most of these studies take the form of material catalogues in excavation reports.

²² While some multi-site studies do exist (e.g. Betori et al. (2009); Bruno (1998); Melli (2004); Spagnolo Garzoli et al. (2008)), they rarely extend beyond the administrative boundaries of the various *soprintendenze*. Exceptions to this are studies of single features such as rivers and roads, which cross multiple administrative areas (e.g. Bosio (1991); Calzolari (1992); Cera (1995); Cera (2000); Medas (2018); Ortalli (1992); Uggeri (1987)), or studies relating to the distribution of single ceramic types (e.g. Bruno (2005a); Cipriano (2009); Cipriano and Mazzocchin (2018); Kenrick (2000)).

²³ From this point forward, the term Northern Italy will be used exclusively in relation to this highlighted area.

²⁴ A summary of the debate up until the mid-2000s can be found in the introduction of *The Cambridge Economic History of the Greco-Roman World* (Morris et al. (2007b)). The minimalist interpretation, figure-headed by Moses Finley and his influential book *The Ancient Economy* (Finley (1999)), posits that the Roman economy was that of a pre-capitalist and pre-industrial society, one in which long-distance trade was limited to high-value goods and the majority of economic activity was based around subsistence agriculture. This is opposed by the maximalist interpretation, first championed by Michael Rostovtzeff (1926) in *The Social and Economic History of the Roman Empire*. The maximalist interpretation believes that the Roman economy exhibited modern characteristics, such as free-markets, production to surplus, and extensive long-distance trade in both staple and luxury goods. While the debate between these opposing positions helped to significantly advance the study of the Roman economy, in recent years there has been criticism of its increasingly stagnant nature and calls to move beyond such polarised interpretations (Hitchner (2005); Jongman (2002); Saller (2005); Scheidel (2012)).

in the interpretation of the ancient evidence.²⁵ However, significant regional variation existed in the Roman economy, something that state-wide models struggle to reflect.²⁶ Recent research has shifted away from attempting to create models that cover the entirety of the Roman economy, to a focus on individual regions and the connections between them. Archaeology has played a key role in highlighting this variation. Prior to the twenty-first century, research on the Roman economy was principally grounded in the study of ancient literary and epigraphic evidence.²⁷ The widespread application of archaeological evidence to the study of the economy has only truly occurred over the past twenty years, but quickly made its mark in challenging prior minimalist interpretations. The Oxford Roman Economy Project (OXREP) has been an instrumental driver in the shift towards recognising regional variation.²⁸ Directors Alan Bowman and Andrew Wilson stress the importance of undertaking detailed regional analysis, ‘precisely because among the things we want to know about the Roman Mediterranean over time are the key similarities, differences, and connections from region to region, as part of a single economy or economic system, or simply as a number of small ‘economies’ linked to a greater or lesser degree’.²⁹

²⁵ For examples of models of the Roman economy, see Bang (2008); Duncan-Jones (1974); Finley (1999); Garnsey and Saller (1987); Hopkins (1980); (1996); Mattingly (2011); Rostovtzeff (1926); Temin (2013).

²⁶ Bowman and Wilson (2009a), 8. There have been some attempts to account for regional variation in Roman economic models, but this has achieved mixed success. Hopkins’ ‘Taxes and Trade’ model (Hopkins (1980); (1996)), acknowledged regional variation to an extent in its explanation of economic interaction between the ‘core’ and the ‘periphery’ of the Roman world. Despite the model’s longevity and popularity, its conclusions have been systematically challenged in recent years (Bowman and Wilson (2009a), 30; Franconi (2014), 8-26). Mattingly’s model comes closest to reflecting regional variation, in that it interprets the Roman economy working as a combination of separate structures defined by their geographic scope and economic influence (Mattingly (2007), 221; (2011), 138-45). Whilst more refined than Hopkins’ model, Mattingly’s grounds itself in the artificial limitations of administrative provincial boundaries. It does not account for the presence of economies that were defined by geographical features, such as river valleys, seas, or mountain ranges - features that could be contained either within a province or cross provincial lines. These ecological limits likely had a significant impact on defining economic activity (Bresson (2005), 95-104).

²⁷ Although there were notable exceptions, e.g. Greene (1986); Mattingly (1988); (1994); Tchernia (1983); (1986).

²⁸ OXREP’s series of edited volumes have enabled focused study on specific areas of the Roman economy. The volumes are firmly grounded in archaeological evidence and include studies on the rural economy, the exploitation of natural resources, maritime trade, and the role of the state and other institutions in the economy. See Bowman and Wilson (2009b); (2011); (2013); Erdkamp et al. (2015); Tchernia (2016); Wilson and Bowman (2018b).

²⁹ Bowman and Wilson (2009a), 8. Although regional studies have become an important tool in understanding the varied nature of the Roman economy, they must be constructed carefully. Many prior studies of ‘regions’ have been criticised for having been conducted within the confines of national boundaries or other arbitrarily defined limits. These fail to take into account natural barriers and corridors that may prove a more accurate delimitation of regional activity (Knappett (2013), 8). The modern field of economic geography presents a framework around which to construct regional economic studies. Economic geographers believe that space and distance play an important part in regional development and seeks to examine spatial eco-

Horde and Purcell's influential work *The Corrupting Sea* was crucial in promoting the importance of studying individual regions to understand wider economic trends.³⁰ Rather than treating the Mediterranean as a single entity, Horde and Purcell viewed the sea as a collection of interconnected micro-regions or zones.³¹ The diversity of the Mediterranean world, with its varied climates and resources, necessitated the forging of connections between these zones in order to compensate for regional inequalities. Central to this theory was the concept of dispersed hinterlands, the notion that cities and territories were not limited to their immediate geographic neighbours for trading but could make use of their sea-borne connections to source goods and materials from much further afield. In this way, a city on the coast might be 'closer' in terms of culture and consumption to a region on the other side of the Mediterranean than to an adjacent inland area twenty miles away. On the back of *The Corrupting Sea*, trade (principally long-distance) has formed an important research area in the study of the Roman economy. Archaeological evidence, in the form of shipwrecks, harbours, and material assemblages of traded goods, has demonstrated that vast quantities of goods and materials were moved great distances across the Roman world. This has allowed more nuanced conclusions on the nature of long-distance trade to be drawn and made minimalist theories on the limited nature of this exchange untenable.³² However, the majority of these studies have focused on maritime trade.³³ Inland trade, its mechanics and how they may be reflected in the archaeological record, remain somewhat understudied.³⁴

conomic discrepancies by applying economic theory in physical contexts (Combes et al. (2008), xviii-xx; Krugman (1991)). Central to the theory of economic geography are the importance of both first-order (naturally occurring, such as resources and climate) and second-order (landscape changes arising from human activity) spatial dynamics in affecting economic development (Cronon (1991)).

³⁰ Horde and Purcell's (2000) model of Mediterranean interactions has remained highly relevant, and continues to form a backbone for studies engaged in regional economic diversity and connectivity across the Roman Empire (Wilson and Bowman (2018a), 4-5). However, *The Corrupting Sea's* methodology is not without flaws, and its ahistorical nature and focus on small-scale trade has been a source of criticism (see Fentress and Fentress (2001), 205-9, 210-11).

³¹ Horde and Purcell (2000), Chapters 4 and 5.

³² This is compared to earlier studies of long-distance trade (for example Morley (2007); Bang (2008)), which only engaged with the archaeological evidence in a superficial manner.

³³ For example, Brandon et al. (2014); Harris and Ira (2011); Keay (2012); Morley (2007); Rice (2012); (2016); Robinson and Wilson (2011); Tchernia (2011); (2016).

³⁴ The only volume to specifically engage with the unique circumstances around inland economies and trade in the Roman period has been *Local Economies? Production and Exchange of Inland Regions in Late Antiquity* (Lavan (2015b)). Although predominantly focused on the Late Antique, several chapters dealt with earlier periods (e.g. Lewit (2015) on the inland trade of Gallic sigillata). The inland circulation and spread of individual material types has been studied to varying levels of depth, though too often this analysis is limited to distribution maps (e.g. Kenrick (2000); Lindhagen (2009); Mees and Polak (2013); van den Berg (2012)). Excavated materials such as ceramics form a useful proxy for examining the mechanics of in-

Transport costs have heavily shaped current thinking behind the mechanics of inland trade, and it has been hypothesised that there would be a steep drop off in the distribution of imported goods as one moved further inland due to the high cost of terrestrial transport.³⁵ This would contrast with the far more extensive distribution of imports in coastal areas due to the low cost of maritime transport. However, this model is somewhat simplistic. For example, Fulford highlights the sustained inland distribution of Dressel 20 amphorae from the Iberian Peninsula to the Empire's northern frontier.³⁶ State actors may have formed an important driving force behind this, leading to differences in distribution between trade facilitated by the state and that conducted by private individuals. Fentress further discusses the impact of political and economic geography on inland economies in North Africa, where she highlights how the dual economic systems of the inland city of Sétif allowed some of its produce to be traded long distances, while other produce remained uncompetitive outside of local markets.³⁷ Furthermore, not all goods would have been traded inland in the same way. African cookwares were widely distributed in coastal regions yet have very little penetration inland.³⁸ This is in stark contrast to fine African Red Slip ware (ARS) which has far greater inland distribution.³⁹ The relatively cheap cookware was less able to absorb transport costs in comparison to the more expensive ARS. Stone and marble cargoes could also move in an atypical way. Imported stone, in the form of revetment, sarcophagi, sculpture, or architectural elements, was able to travel great distances inland in some circumstances.⁴⁰ The expense and financing behind stone and marble items (especially for monumental architecture and sarcophagi) might mean that transport costs were something the commissioner could readily afford. The picture that emerges is far more complex than a simple drop-off of imported goods as distance from the coast increased, with myriad factors affecting inland distribution.

One feature that significantly complicates the model of a linear regression of imports from the coast is the presence of a navigable river. The Roman Empire

land trade (for example, the inland spread (or lack thereof) of African ceramics, Bonifay (2003); (2018); Leitch (2011)), but more remains to be done to link the results of material studies into wider debates.

³⁵ Bonifay (2018); Fulford (2009), 253; Lavan (2015a); Vaccaro and MacKinnon (2014).

³⁶ Fulford (2009), 254. See also Carreras (1994a). Gallic terra sigillata would see a similar sustained inland distribution across the northern provinces (Mees and Polak (2013)).

³⁷ Fentress (1990). See also Fentress (2013) on inland textile production in North Africa, alongside Fentress (1979) for inland military supply.

³⁸ Leitch (2011); (2013).

³⁹ Bonifay (2003); (2018).

⁴⁰ Although it is important to note that the long-distance trade of stone and marble constituted an exceptional phenomenon. The majority of stone in the Roman world travelled over very short distances (Russell (2013), 143; (2018b), 240-42).

contained some of the world's largest rivers, including the Rhine, Danube, Po, and Rhône, parts of the Nile and Euphrates, alongside thousands of smaller waterways.⁴¹ Both upstream and downstream fluvial transportation was significantly cheaper than overland transport, and river vessels allowed greater quantities of cargo to be transported compared to terrestrial vehicles, with the largest barges able to move up to one hundred tonnes.⁴² This allowed navigable river networks to create corridors of lower-cost travel from the coast, enabling imported goods to penetrate further inland in greater quantities and allowing inland produce to move in the opposite direction.

Over the past decade, rivers have received increased attention, with the first comprehensive synthesis of evidence and scholarship, *Rivers and the Power of Ancient Rome*, published in 2012.⁴³ In particular, there is a growing understanding that rivers require human input in order to fulfil their potential as transport corridors.⁴⁴ Specific conditions need to be met for navigation, conditions that were even more stringent for larger, heavier vessels.⁴⁵ Seasonality, weather, and channel morphology affected the state of the river, while significant infrastructure in the form of docks, warehouses, and towpaths were needed for the loading, unloading, and haulage of river vessels. Consequently, despite the advantages of fluvial transportation and the important role it played in inland trade, river transport could be unpredictable. Furthermore, roads were crucial for moving goods to areas not in the immediate proximity of the watercourse.⁴⁶ Indeed, Laurence emphasises that 'to discuss water and land transport as competing systems . . . is to misunderstand the economics of transport in the Roman world'.⁴⁷ Most inland journeys would have utilised a combination of the two.

Beyond transportation and connectivity, river valleys form important eco-

⁴¹ Even very small rivers could support traffic. For example, the wreck of a barge carrying a cargo of roof tiles was discovered in the 47 km long river Stella in Friuli-Venezia Giulia, Italy (Castro and Capulli (2016)).

⁴² Bockius (2004), 482; Bondesan et al. (1990), 13. The figures for the monetary cost of transport in the ancient world have their basis in Diocletian's Price Edict of AD 301, however, only the Aphrodisias copy of the Edict differentiates between the cost of upstream and downstream river transport (*Edict of Maximum Prices*, XXXVA.31-33; Erim and Reynolds (1970)).

⁴³ Campbell (2012). See also Franconi's (2013) review, alongside Franconi (2017b) for more focused discussions on aspects of Roman rivers.

⁴⁴ Adams (2007); (2012); Franconi (2014), Chapter 2; (2016); (2017b); (2017a); Rieth (1998).

⁴⁵ Paleohydrology and paleoclimatology have both played important roles in examining the characteristics of rivers during the Roman period. Rivers are not static landscape features and are constantly evolving. Indeed, many rivers that were navigable in the Roman period, such as the Scrivia and Reno, are no longer navigable in the modern period. Edgeworth (2011); Macklin et al. (2012); Izdebski et al. (2016).

⁴⁶ Hitchner (2012). It is, however, worth highlighting that the shallow gradient present on the floor of river valleys could reduce the difficulty of terrestrial transport and present more direct connections than the paths offered by hillier terrain.

⁴⁷ Laurence (2005), 138.

conomic zones. The fertile alluvial soil of the floodplain could be the source of considerable agricultural wealth, with rivers also providing sources of water for both arable and pastoral farming and supporting other food production activities such as fishing. The agricultural productivity of river valleys allowed them to support larger populations and produce an agricultural surplus for export, most famously in the Nile and the Guadalquivir valleys which supplied grain and olive oil to Rome respectively.⁴⁸ Italy itself contained several major river valleys, most notably the Tiber valley. However, the largest of these, and the least studied, is that of the Po and its extensive network of tributaries.

1.2 Northern Italy and the Po Valley

The Po valley's location and unique geography make it (and Northern Italy more generally) a perfect case study to explore questions related to inland trade during the Roman period. The region forms a transitional zone, a meeting point between the Eastern and Western Mediterranean along one axis, and the Italian peninsula, and Northern Europe along the other. How did goods and people move through the region between these places? Where did the region import goods from and export goods to? To the north, the Alps create a formidable (although not insurmountable) barrier to movement, beyond which lay the north-western provinces of the Empire. To the south, the Apennines form a physical separation between the Po valley and the rest of the Italian peninsula. To what extent did these mountains hinder movement and trade? Northern Italy also possesses two coastlines, the Adriatic and the Ligurian, with the ports upon them offering competing entry points for extra-regional imports. One coast faced the Adriatic and, beyond it, the Eastern Mediterranean, while the other faced the Western Mediterranean. Yet the Ligurian Sea was separated from the Po valley by the Ligurian Apennines. How did this affect the movement of imports and exports within the region? Was one coastline favoured over the other? The Po valley itself comprises of a large alluvial plain through which flows one of the largest navigable rivers in the Roman world. How did the valley's geography and navigable rivers aid the distribution of goods and people?⁴⁹ What was being produced

⁴⁸ Adams (2018); Blouin (2014); Erdkamp (2012); Ponsich (1974); (1979); Remesal-Rodríguez (1980); (1997); (1998).

⁴⁹ Despite being one of the largest rivers within the Roman world the importance of the Po and its tributaries, alongside their usability as transport arteries, has at times been questioned or underplayed (e.g. Brunt (1971); Chilver (1941); Harris (2011b)). However, extensive archaeological evidence for port infrastructure, alongside literary and epigraphic evidence for navigation, makes this position untenable (for archaeological evidence of navigation see Cera (1995); Medas (2003a); (2018); Uggeri (1978); (1987); (1998). For literary and epigraphic evidence, see Bargnesi (2004); Broekaert (2013); Calzolari (2004); Gabucci and Mennella (2003)).

in this fertile region and where was it being consumed? However, despite its potential, the Po valley has failed to inspire the focused regional economic studies that have been undertaken in the Tiber valley (perhaps the best-known and most comprehensively studied river valley in the Roman world) and other large river basins such as those of the Rhône and Nile.

Although Northern Italy holds significant promise as a case study of inland trade, most prior regional scholarship has focused on examining its social history. Historians, in particular, have predominantly engaged with the Roman expansion into Cisalpina and Transpadana during the mid-Republic, and their eventual incorporation into Italy in 42 BC.⁵⁰ Through the lens of these studies, the Po valley constituted a frontier region, a border between the Roman south and the Celtic north. As the region possesses Italy's border with Northern Europe it has always been the point of entry for land invasions of the Italian peninsula and the region was no stranger to conflict during the Roman period. The Po valley would serve as the theatre for the opening engagements of the Second Punic War, with the major battles of Trebia and Insubria taking place alongside dozens of minor actions.⁵¹ Marius, at the Battle of Vercellae, would defeat the Cimbri and Teutones in 101 BC and the Emilian plain hosted the first major engagements of the civil war that followed Caesar's death.⁵² Beyond that, Augustus would campaign against the Salassi in the Alps, who revolted in 34 BC, and again in 25 BC.⁵³ The region would see further conflict throughout the Imperial and Late Antique Periods. The Po valley would be the location of several battles

Although the potential of the Po water network to support navigation and trade is viewed more positively than it was fifty years ago (Campbell (2012), 302-7; Laurence (1999), 114-22), the river remains somewhat neglected in comparison to the study of other similar sized Roman waterways.

⁵⁰ See Brunt (1971); David (1997); Peyre (1979); Dyson (1985); Harris (1985); Häussler (2007); (2013); Lomas (2017); Purcell (1990); Roncaglia (2018), Part I; Salmon (1982); Williams (2001). Little attention has been given to the Imperial history of the region. Chevallier's (1983) influential work *La Romanisation de la Celtique du Pô. Essai d'histoire provinciale* remains the most comprehensive history of Northern Italy during the Imperial period, although Roncaglia (2018), Part II provides several important reassessments. Caesar would grant the inhabitants of Gallia Cisalpina Roman citizenship in 49 BC via the *lex Roscia*, but it would not be until 42 BC that the province was incorporated administratively into Italy.

⁵¹ The major Roman defeat at Trebia near Parma was preceded by several skirmishes, notably around Pavia and Piacenza (Livy 21.47-58.).

⁵² These were the battles of Forum Gallorum and Mutina in 43 BC (Appian 3.67-72; Dio 46.37-39).

⁵³ On the 35 BC campaign see Dio 49.34, 49.38. For the 25 BC campaign, see Dio 53.25. Aosta would be founded on territory confiscated from the Salassi. Campaigns were also undertaken between 17 and 14 BC against the Cammuni, the Vennii, and the Rhaetians in the area of Trentino (Dio 54.20-22; Suetonius, *Augustus* 21; *Tiberius* 7; Velleius Paterculus, 2.95). Their subjugation, along with other Alpine peoples, is recorded on the Tropaeum Alpinum at La Turbie (CIL V 7817), and commemorated by triumphal arches at Aosta and Susa. Client kingdoms, such as that of that of the Cottiae in the Western Alps in the territory of Susa, would also survive into the latter half of the first century AD (Roncaglia (2013), 334-35).

in the Year of the Four Emperors, AD 69, most notably that of Cremona but also actions at Piacenza and along the Po itself.⁵⁴ Northern Italy would also be invaded during the Marcomannic Wars of the second century AD, with Aquileia besieged and Oderzo razed to the ground.⁵⁵ Further conflict would follow during the civil wars of the third century, and the region would see repeated incursions from the Alemanni, Juthungi and Marcomanni during this time.⁵⁶ This unrest would see the increasing militarisation of Northern Italy, culminating with the stationing of permanent military garrisons at Milan and Pavia, and the movement of an imperial capital to Milan in the late AD 280s to allow the emperor to be nearer the frontier.⁵⁷ The perception of Northern Italy as a buffer zone between Northern Europe and the Italian Peninsula has served to promote narratives of assimilation, either through conquest or ‘Romanisation’, which in turn reinforce the idea of the region as geographically and socially distinct from Central Italy.⁵⁸

The view of Northern Italy as separate or cut-off from the rest of the Italian peninsula has helped to foster concepts of isolation amongst some scholars, proving an especially common theme amongst the limited discussions of the region’s geography and economy.⁵⁹ This perception of isolation, both social and geographic, can be traced back as far as the middle of the twentieth century when the first regional studies were undertaken. The first to examine the valley in detail was that of Chilver in 1941. Chilver covered the history of Cisalpine Gaul from the enfranchisement of the Transpadani in 49 BC up to the death of Trajan in AD 117, specifically concentrating on the social and economic development of the region. Writing at a time before any large-scale archaeological investigation had taken place, he concluded that the Cisalpine economy could have been of little more than regional significance due to its inability to export its produce.⁶⁰ Brunt, in his *Italian Manpower 225 B.C.-A.D. 14*, would reach a similar conclusion, describing Northern Italy as ‘largely cut-off from trade with other parts of Italy, Gaul, or the Mediterranean at large’.⁶¹ One of the main issues that both Chilver and Brunt highlighted as an obstacle to the economic development of

⁵⁴ Suetonius, *Vitellius* 10; *Vespasian* 7; Tacitus, *Histories* 2.1-51; 3.1-25.

⁵⁵ SHA, *Marcus Aurelius* 14.

⁵⁶ Aurelius Victor, *De Caesaribus*, 28.10; 33.1-18; Zosimus 1.22. The emperors Philip the Arab, Decius, Gallienus, all fought in Northern Italy. Roncaglia ((2018), Chapter 8) contains a good summary of the history of the region between the third and sixth centuries AD.

⁵⁷ Aurelius Victor, *De Caesaribus*, 33; *Epitome de Caesaribus* 34. After the fall of the Western Empire, the Po valley would form a major battleground in the Gothic Wars of the sixth century (Procopius, *History of the Wars*).

⁵⁸ Millar (1995), 211; Patterson (2006); 2; Roncaglia (2013), 1-18.

⁵⁹ See Chilver (1941); Brunt (1971); Harris (2011b); Millar (1995); Patterson (2006); Purcell (2012); Scheidel (2014).

⁶⁰ Chilver (1941), 29-35, 135.

⁶¹ Brunt (1971), 180-81.

the Po valley was the perceived absence of a large port at the mouth of the Po delta, an argument that would be further developed by Harris in his 1989 paper, ‘Trade and the River Po: A Problem in the Economic History of the Roman Empire’.⁶² Harris believed this to be a result of the Po’s regime being too difficult to navigate, the valley having nowhere to trade a surplus to, and the region’s cities having little interest in importing large quantities of foreign goods.⁶³ Notions of the region’s geographic isolation have persisted well into the twenty-first century. To give an example, Scheidel, in his 2014 article on modelling connectivity across the Roman Empire, singles out the ‘isolation’ of Northern Italy from the rest of the Italian Peninsula.⁶⁴ However, Scheidel’s model maps connectivity specifically from Rome across the Empire. Does this also mean that the Po valley was isolated from markets in Germany, Gaul, Illyria, or the Eastern Mediterranean? Taking a Rome-centric viewpoint is unhelpful when discussing regional connectivity; despite this, it has proved surprisingly common in Anglophone scholarship concerned with the Po valley.

The most recent regional study, Roncaglia’s 2018 book *Northern Italy in the Roman World*, forcefully challenges perceptions of the social, geographic, and economic isolation of Northern Italy from the rest of the Italian Peninsula and wider Roman world.⁶⁵ Roncaglia’s work contains the most complete synthesis of information on the development of the region’s economy to date, including information on agricultural production, more specialised economic activity, and trade.⁶⁶ Whereas prior studies have tended to concentrate solely on the early Roman history of the valley, specifically during the Republic, Roncaglia integrates the region’s pre-Roman and Late Antique history into her analysis, giving a far more comprehensive overview of the area’s development than has been previously available. While Roncaglia’s study is a welcome addition to the body of litera-

⁶² Harris (2011b), 115. The essay would be edited and republished as part of the 2011 volume, *Rome’s Imperial Economy: Twelve Essays*. Harris and his predecessors were writing at a time before the advent of widespread palaeo-geomorphological investigations. These would later show that the main mouth of the Po during the Roman period was located close to the port of Ravenna (see Section 2.2).

⁶³ Harris (2011b), 196-7. Harris’ analysis was principally based on literary, artistic, and epigraphic evidence and whilst some of his ideas are well presented, his argument was weakened by a lack of access to archaeological evidence. Indeed, when Harris republished his paper on the Po in 2011, he admitted in the introduction that, in retrospect, his argument stemmed from a lack of evidence at the time of publication (Harris (2011a), 5).

⁶⁴ Scheidel (2014), 21.

⁶⁵ Roncaglia (2018). Her study is primarily focused on the eastern and central valley, specifically the areas to the east of Lake Como and Milan, and the route of the via Aemilia. While this area has produced some of the most detailed scholarship in the region, the western valley, specifically the territory of Piedmont, warrants further attention.

⁶⁶ The evidence compiled for textile production is particularly important. Textiles are emphasised as an important regional export from Northern Italy in ancient literature yet are something that does not survive in the archaeological record (Roncaglia (2018), 90-94).

ture on Northern Italy, its examination of the region's economy could have been developed in even greater detail. Crucially, engagement with the archaeological evidence in most economic regional studies (including Roncaglia's) remains, at best, superficial.⁶⁷

Although the majority of regional scholarship available for the economy of Northern Italy remains grounded in the literary and epigraphic evidence, a half-century of archaeological investigation has provided a wealth of new data.⁶⁸ At a sub-regional level, there has been extensive investigation undertaken by Italian archaeologists working under the jurisdiction of the *soprintendenze* or northern Italian universities. Under their guidance, dozens of rescue excavations have been carried out in the region, including major urban excavations at important Roman cities such as Aquileia, Brescia, Milan, and Verona.⁶⁹ While not every excavation has been published, many have been studied to a high standard. Material specialists in amphorae, finewares, and stone (alongside other artefacts), have produced catalogues of quantified data for individual excavations, offering detailed insight into the sites under investigation. Unfortunately, this material is rarely analysed in a wider context. There have been some attempts to compare material from sites located within the same *soprintendenza* jurisdiction, alongside several discussions surrounding individual artefact types at a regional level (for example the distribution of Dressel 6A and Lamboglia 2 amphorae across Northern Italy), but these are seldom integrated into wider discussions on the Roman economy.⁷⁰ Analysis of both short and long-distance trade within Northern Italy has rarely passed beyond the use of distribution maps of material. While these are useful

⁶⁷ Studies that have included archaeological evidence (e.g. Broadhead (2000); Chevallier (1983); Garnsey and Saller (1987); (1998); Roncaglia (2018)), have taken a far more positive view of the region's economy. However, few choose to examine the original evidence itself and draw somewhat simplistic conclusions from its interpretation. For example, in Roncaglia's study, the economic analysis does not move beyond the port of Aquileia and its role in long-distance trade, alongside the creation of several distribution maps of various amphora types found within the region (Roncaglia (2018), 101-15). Garnsey ((1998), 13-18) and Broadhead ((2000), 156-57) take a similar approach, citing the existence of imported amphorae as simple proof of long-distance trade. This hides the true complexity of picture presented by the archaeological evidence.

⁶⁸ A lack of engagement with archaeological evidence when discussing economic history is not something unique to Northern Italy. The inaccessibility of many material studies and their lack of engagement with broader economic questions, has often led to them being side-lined in wider economic discussions. See, for example, Bang (2008); (2012); Finley (1999); Lo Cascio (2009); Morley (2007); Morley (2012); Morris et al. (2007a); Whittaker (1993); (1994).

⁶⁹ See Brogiolo (1999); Caporusso (1991b); Cavalieri Manasse (2008b); Filippi (1997); Fontana (2017); Maggi et al. (2017).

⁷⁰ Examples of multisite studies include Betori, Gomez Serito, and Pensabene's (2009) analysis of stone and marble types used in Roman monuments in the western Alps or Bruno (1998) and Melli's (2004) studies on trans-Appennine trade. For examples of studies focusing on single artefact types, see Bruno's (2005a) gazetteer of amphora types found within Northern Italy; Zara's (2018) study of the quarrying, distribution, and use of Euganean trachyte; or Cipriano and Mazzocchin's (2018) analysis of the development of Dressel 6A amphorae.

for observing the spread of artefacts, they fail to map the intensity of trade by distinguishing between what might be termed ‘one-off’ imports and more sustained trade.⁷¹ The majority of quantified material analysis remains limited to a site-by-site basis, resulting in a huge amount of excavated material that has never been studied outside of its find context.

1.3 Methods and Approaches

To answer the questions outlined in this introduction, the thesis approaches the ancient evidence in several distinct ways. The advance of modern spatial and statistical analytical techniques over the past decade has had a large impact on the study of the Roman economy.⁷² Indeed, the potential of statistical analysis is readily apparent, as it offers a way to scientifically test theoretical models, study large datasets, and overcome flaws or limitations inherent within archaeological data.⁷³ The approach taken in this thesis uses a combination of spatial network analysis and quantitative statistical analysis to examine the archaeological data from the region. Network analysis is used to create a model of the ancient transport network in the first part of this thesis, allowing the cost and time of transport from defined entry points to be measured across the region. A methodology for this analysis is included in Chapter 4, with additional data available in Appendix A. Quantitative statistical analysis is used in the second part of the thesis to analyse material datasets of amphorae, finewares, and decorative stone from the study area. Similarities in their provenance and the diversity of their contents

⁷¹ For example, Kenrick (2000); Lindhagen (2009); Mazzocchin (2009).

⁷² Despite their usefulness, the application of network and statistical modelling as tools of analysis has not been without critics. Some have questioned whether modern analytical techniques can be used to rigorously test primitive aspects of ancient economies without an inbuilt bias against them (See Van Oyen’s (2017) response to Brughmans and Poblome (2016b), alongside Brughmans and Poblome’s (2017) reply). Others have queried the necessity of applying statistical analysis outside of specific scenarios, calling out the fads in scholarship behind some types of analysis and the bad science present in papers that do not fully understand the methodology they are applying (Collar et al. (2015); Reinhart (2015); Smaldino and McElreath (2016); Thomas (1978)). The accessibility of computational studies has also been criticised. Papers engaged in network or statistical analysis contain technical language that places a barrier between those who can actively engage with their methodology and those who cannot. As a result, their readership (and the reach of their conclusions) may be limited. Despite these criticisms, when applied carefully, computational analysis is a valuable tool for the interpretation of archaeological data. Choosing the right methods to apply to the data, alongside defined research questions, help to ensure the validity of a model’s results (Knappett (2013)).

⁷³ See, for example, the paper by Rubio-Campillo et al. (2017) that uses similarity measures to explore whether the Atlantic or the Rhone valley was the more likely route used to transport Dressel 20 amphorae to Britain and the northern provinces; Romanowska et al. (2021), who use simulation to test theories relating to the apparent dominance of local ceramics (99% of ceramic finds) in Jerash; or Snyder et al. (2018), who use agent-based network modelling to hypothesise how the construction of Constantinople’s water infrastructure was managed.

are measured and compared geographically and chronologically across Northern Italy. A full methodology for the statistical analysis is presented in Chapter 5, with additional data available in Appendices B and C. The following section lays out the strengths, criticisms, and uses of each approach.

1.3.1 Network Analysis

The use of network analysis in archaeology has grown exponentially since the 1990s, as greater interdisciplinary cooperation between statisticians, computer scientists, and archaeologists made the necessary skills and software more available.⁷⁴ Network modelling – the mapping of nodes and connections (also known as edges) between sites, people, or materials – has been used to explore a range of archaeological questions. The types of network analysis utilised can be broadly split into two methodologies. The first is Social Network Analysis (SNA), where network graphs map relationships amongst sets of social actors, such as the spread of messages and ideas.⁷⁵ The second is Spatial Network Analysis (SpNA), where the nodes and edges represent features that exist in real geographic space.

Of the two methods outlined above, SpNA is best suited to analyse real-world transport networks and has been widely applied in the study of Roman trade and transportation.⁷⁶ Within a spatial network, the nodes of the model might represent cities, towns, and villages, while the edges between them might represent the routes of the roads, rivers, or sea-lanes connecting them. The greater the number of nodes and edges within a set geographic area a model possesses, the more detailed it is. Furthermore, each node and edge can contain data. For an edge, this might relate to the distance of its length, the cost and time it takes to travel along it, or a value to represent connectivity. For a node, values might include delays or penalties in the form of transshipment costs. The values applied to nodes and edges can originate from ancient transport data (such as the costs

⁷⁴ Brughmans (2010); (2013); (2022); Collar et al. (2015); Knappett (2013); Mills (2017). The ability of network analysis to handle and visualise large, complex datasets, alongside its compatibility and ability to complement other, more established tools such as GIS, has helped drive its adoption within the archaeological community.

⁷⁵ One of the most influential uses of Social Network Analyses in the study of the Roman economy was performed by Tom Brughmans and Jeroen Poblome as part of Project MERCURY (Brughmans and Poblome (2016a)). Brughmans and Poblome used a network model to simulate the movement of Eastern Terra Sigillata based on the theories of economic integration proposed by Peter Bang (2008) and Peter Temin (2013), discovering that the evidence more closely matched Temin’s hypothesis of free market trade (Brughmans and Poblome (2016b)). Project MERCURY, which aims to equip scholars with the skills needed to undertake computational analysis by supplying tutorials, datasets, and a model library, has been instrumental in raising the profile of network modelling as an analytical tool amongst classical archaeologists.

⁷⁶ See, for example, Brughmans (2013); Carreras and De Soto (2013); De Soto (2019); De Soto and Carreras (2014); Graham (2006); Isaksen (2008); Orengo and Livarda (2016); Preiser-Kapeller and Werther (2018); Scheidel (2014).

listed in the fourth century AD Edict of Maximum Prices), or later comparative data. By analysing the network routes, SpNA can be used to create maps of cost in money and time across an ancient transport system or measure complex aspects of the network such as its connectivity (measured using metrics such as betweenness, closeness, or degree centrality).⁷⁷

Prior applications of network analysis to the Italian peninsula's transport network have been limited in scope, either forming part of larger network models of transport in the Roman Empire or lacking the data to create a sufficiently detailed network graph.⁷⁸ This thesis uses archaeological data to reconstruct the ancient road, river, and canal work within Northern Italy, allowing the graph it creates to contain a significantly higher density of nodes and edges than previous models and enabling an unprecedented level of detail in its analysis.

1.3.2 Quantitative Material Analysis

As network models can only ever be a heuristic device for the study of the past, it is essential to compare their results against other data to gauge their accuracy. In the absence of ancient records detailing trade, it is necessary to consult proxies as a stand-in for this missing data.⁷⁹ Quantified datasets of excavated material provide a body of proxy evidence with which to perform this comparison. The quantity and concentration of these objects can give some indication of past patterns and trends in trade, such as the level of penetration of certain goods, where they were originating from, and how this changed over time. This thesis uses three types of material in its analysis: amphorae, red-slipped finewares, and decorative stone revetment. In an ideal world, more datasets beyond just amphorae, finewares, and stone would be brought to bear on this study. Metal, glass, and even archaeo-botanical finds of 'exotic' items such as spices can help to highlight patterns in trade and consumption.⁸⁰ However, the constraints of the thesis meant it was necessary to limit the types of material analysed to the best published and most available.

One of the key objectives of OXREP has been to promote a more rigorous

⁷⁷ De Soto (2019), 278-80; Golbeck (2013), 23; Orengo and Livarda (2016), 23-26.

⁷⁸ The Stanford ORBIS model included the Italian peninsula in its network analysis, but as its scope included the entirety of the Roman Empire, it was necessary to reduce the density of the nodes and edges to ensure the workability and legibility of the model (Mees and Polak (2013); Scheidel (2014)). The other major network model to cover the Italian peninsula is that of Carreras and De Soto (2013). The model, despite covering a much smaller geographical area than ORBIS, contained a similar resolution of detail.

⁷⁹ It is important to choose the correct type of proxy data for the question being researched. All proxy data has limitations and studies based on poorly quantified or misunderstood proxies have been challenged (Wilson (2009b); Wilson (2014)).

⁸⁰ See Livarda and Orengo (2015); Orengo and Livarda (2016).

analysis of existing archaeological data, with an emphasis on moving towards quantified studies of economic activity.⁸¹ Quantified studies enable the analysis of trade to move beyond simple distribution maps, allowing the intensity of trade by distinguished between ‘one-off’ imports and more sustained connections. While some superficial patterns can be observed by simply comparing quantified data, statistical methods form important analytical tools, often revealing underlying patterns not visible to the naked eye. Statistical analysis is especially useful when examining large datasets, providing a way to quickly locate underlying trends hidden by the volume of material contained within them. For example, hierarchical clustering such as the UPGMA (unweighted pair group method with arithmetic mean) algorithm, can be used to find groups of sites with aligned material assemblages, while similarity indexes, such as Simpson’s Index or the Morisita-Horn Overlap Coefficient can be used to measure the diversity of the materials present at and between sites.

Although the rise of quantified studies has improved understanding of the Roman economy, they are not without their problems.⁸² Archaeological data contains biases, either inherent (such as survivability) or acquired (such as through excavation practice), and it is important to acknowledge these weaknesses in the data.⁸³ A lack of standardisation amongst the values used to quantify excavation data often forms a significant hurdle to comparing datasets from multiple sites. For example, ceramic finds can be quantified by total number of sherds, minimum number of individuals (MNI), or number of rims, bases, and handles (RBH). A publication might include all of these measures of quantification or only a single type. Even where the same values are present across multiple site publications, it is often not as simple as comparing like-with-like. Quantified datasets of stone might include the number of fragments of wall revetment but also sarcophagi and monumental architectural elements. These are neither comparable in size nor function, and were traded through different mechanisms. It is crucial to ensure that the data being analysed are truly comparable, and comparisons between quantified assemblages must be carefully constructed, taking the flaws and limitations into consideration.

A study that unites the individual, quantified material datasets from across Northern Italy has the potential to answer complex questions on the region’s econ-

⁸¹ Bowman and Wilson (2009a), 3; Peña (2007a).

⁸² Wilson (2009b); (2014). Some, such as Fulford, have called for a greater focus on consumption as a way to overcome some of the inherent flaws in excavation data (Fulford (2009), 251-52). In a similar vein, Russell ((2013), 144) has argued for the adoption of ‘consumption’ maps instead, where the origin of imported goods to a region are mapped, as opposed to their distribution on arrival. See also Russell (2018b), 240.

⁸³ Wilson (2009a); (2009b); (2014).

omy. In particular, by comparing and contrasting material from different sites, geographical and chronological patterns and trends in trade and consumption across the region can be brought to light. Amphorae, finewares, and stone were traded through different mechanisms and consumed in different ways. Through comparing different types of material (in this case amphorae, finewares, and stone), a greater depth of understanding can be gained of the varying levels of exchange undertaken in the region and the different supply mechanisms behind them.

1.4 Structure

This thesis examines the dynamics of inland trade within Northern Italy between the first century BC and the fifth century AD. It analyses the complex dynamics around the trade of local and imported goods, and how these changed chronologically and geographically across Northern Italy. The focus of this thesis is on the circulation of goods within Northern Italy, primarily imports traded long-distances but also items produced within the region. Although Northern Italy also exported numerous products, such as terra sigillata, wine, and grain, the space constraints of the thesis meant that patterns of export could not be examined in detail (although they are briefly covered in Chapter 9). The thesis examines the interplay and co-dependency of terrestrial and fluvial transport, and conclusively proves that the Po formed an important trade artery across the region. It demonstrates that, despite their distance from the coast, inland sites were connected to Mediterranean markets through long-distance trade. While transport costs played an important part in the distribution of goods and material in inland regions, they did not remove choice. The consumer could play a significant role in the provenance and type of imports consumed across the region. The conclusions of the thesis apply not just to Northern Italy, but to other river valleys and inland trade more widely. The thesis contains nine chapters and is split into three parts:

Part One of the thesis examines the physical environment of Northern Italy and its transport network, before using network analysis to create a model of regional connectivity.

Chapter 2 investigates the geography and hydrology of Northern Italy, describing the physical setting and environment of the study area which forms the backdrop for the network analysis. It uses a combination of palaeohydrological and palaeoclimatological data to reconstruct the past environment of the region, and highlights some of the physical changes the Romans made to the natural landscape (such as mass deforestation, centuriation, and drainage works).

Chapter 3 examines the region's transport infrastructure, creating the network used in the subsequent analysis. Examination of the archaeological evidence demonstrates that between the first centuries BC and AD, significant effort and capital was expended in the creation of new fluvial and terrestrial infrastructure. This extended the transport network into new areas of the region and served to reduce the difficulty of traversing challenging terrains such as low-lying waterlogged ground and steep mountain passes. Evidence for fluvial navigation is also synthesised to create a new catalogue of navigable rivers, revealing many waterways in the region that are no longer navigable would have been during the Roman period.

Chapter 4 details the spatial network analysis undertaken on the region's transport network to explore questions of regional connectivity. The chapter outlines the creation of a route network model consisting of 136 nodes, allowing significantly more detailed analysis than previous models of transport and connectivity in the region. A secondary network, modelling the transport of the heaviest of cargoes such as stone, is also created. Cost (in kilograms of wheat) and time (in hours) are used as measures of connectivity. Cost and time figures for transshipment and gradient, factors rarely included in other network models, are discussed and implemented, alongside figures for the cost and time of canal transport. The model confirms the importance of fluvial transport in reducing the cost of moving goods inland but also highlights that, in some areas of the western valley, there was little difference in the cost and time of transport from the Adriatic and Ligurian coasts.

Part Two of the thesis examines selected material culture from Northern Italy. Quantified assemblages of amphorae, fineware, and stone from thirty-seven urban sites are statistically analysed together for the first time, revealing new geographic and chronological patterns in the provenance and type of goods consumed across the region.

Chapter 5 outlines a methodology for the material analysis and the statistical methods utilised in the subsequent chapters. The scope of the analysis is outlined, while flaws in the amphora, fineware, and stone data are highlighted and solutions proposed to overcome them.

Chapter 6 examines the region's amphora data. Over 19,000 sherds of amphora from thirty urban sites in Northern Italy are statistically analysed and discussed. Changes in the provenance of amphora-borne goods are clearly observed as distance from the Adriatic coast increased. However, the results suggest that inland sites, especially those in the far west of the study area, had greater diversity in both the provenance and type of amphorae than sites in the coastal hinterland.

Chapter 7 examines the region's fineware data. Over 9000 sherds of red-slipped fineware from twenty-six urban sites in Northern Italy are statistically analysed and discussed. The results show that finewares produced in Northern Italy dominated its markets, with imported finewares achieving little penetration until the third century AD. Inland sites retained a higher level of diversity than those closest to the coast in the make up of their assemblages.

Chapter 8 examines the region's stone data. Over 18,000 fragments of decorative stone from thirteen urban sites in Northern Italy are statistically analysed and discussed. The results demonstrate a sharp split between the east and west of Northern Italy. Sites in the east contained greater quantities and varieties of Eastern Mediterranean lithotypes, while sites in the west principally relied on white Luna marble and locally quarried stones.

Part Three of the thesis unites the results of the preceding analyses and incorporates them into wider discussions on river valleys and inland economies in the wider Roman world.

Chapter 9 integrates the findings of the network and material analyses, comparing the results against one another to achieve a greater depth of understanding of the processes behind the distribution of goods in Northern Italy. The results of the analysis are compared to other river valleys in the Roman world, and applied to wider questions pertaining to inland economies. The chapter also contains final concluding remarks and completes the thesis.

Part 1: Landscape and the Transport Network

Chapter 2

Landscape and Hydrology

The natural environment plays an important role in how human landscapes develop. Topography, geology, and climate affect everything from settlement patterns and economic activity, to movement and communication. Plains offered fertile land for agriculture and faster travel, while mountains and hills were more difficult to traverse and formed obstacles. Moreover, in a landscape dominated by water, as the Po-Veneto plain was, the characteristics and behaviour of the river network had a significant impact on the lives and activities of those living nearby. Rivers might enable the easy transport of goods and people between areas, function as a source of water and food, or act as a defensive barrier. At the same time, these rivers could be destructive. Extreme hydrological events, such as floods and low flows, disrupted the lives of those who used or lived around them, while the adjacent marshes and wetlands could form a breeding ground for disease. Geography and hydrology heavily influence the creation of transport networks, and the landscape outlined in this chapter forms the base map of the subsequent network analysis.

Although the modern physical geography of Northern Italy bears many similarities to that of the Roman period, the routes and characteristics of its waterways, have changed dramatically. While natural processes have caused extensive alteration, modern human interventions to harness the power of the region's rivers, extract their resources, and control their flow, means the water network is now as much a human as a natural construction.¹ Subsequently, any analysis of the ancient water network must depend on evidence that predates these changes, such as ancient literature, archaeology, and paleoclimatic and geomorphological data. Prior scholarship has often assumed that the Po was used extensively for

¹ This is not an unusual occurrence. Many European rivers, such as the Rhine, Rhône, and Danube, have seen extensive alteration to their channels since the end of the nineteenth century, as humans have sought to control and exploit waterways. Few are considered to be free flowing any more (Marchetti (2002), 367-70; Surian and Rinaldi (2003), 311-17; Tockner et al. (2009), 4-5).

trade and transport on the basis that it was a major river, with little attempt to examine the effect its hydrology had on the feasibility of such enterprise.² Yet the physical regime of the river, with its potentially variable flow, fast current, destructive flooding, and high sediment load, may also have presented obstacles to rivercraft. Rivers are not static features, nor are they simple lines on a map that can simply be traversed from A to B.³ They are complex, constantly changing parts of a landscape, and their use is heavily dependent on their regime, which, in turn, can be affected by climate, seasonality, and human intervention. Knowledge of the prior characteristics of the region's water network is therefore necessary before testing the validity of these claims and examining its navigability during antiquity.

While natural processes were responsible for the formation of the region's geography, humans were not passive actors in the landscape. During the Roman period, the inhabitants of the Po-Veneto plain undertook significant interventions into the region's territory and rivers, shaping them to better suit the needs of its human settlers.⁴ Many of these initiatives were related to agriculture, in particular widespread centuriation and associated land reclamation schemes, which sought to expand the area of land available for cultivation. In addition, there were considerable efforts to reduce the hydrological risks faced by riparian communities, especially in the middle and lower Po valley which were particularly susceptible. Human interventions helped to further shape the region's landscape, although the resources required for their upkeep meant they often proved temporary.

This chapter explores the natural environment of Northern Italy, exploring the physical geography of the region from its mountainous borders to the marshy delta. Ancient literary, palaeoclimatic, and geomorphological evidence are used to reconstruct the river network's ancient characteristics, with the impact of a changing climate on both the network and its adjacent communities taken into consideration. Finally, Roman interventions into the physical landscape are examined, specifically the large-scale centuriation and land reclamation initiatives that changed the region's natural environment, alongside alterations to its river network aimed at reducing hydrological risk. The locations of sites mentioned within this chapter can be viewed in Figure 2.1.

² For example, Calzolari (2004); Campbell (2012), 302-09; Gabucci (2017); Galvani and Pellegrini (2010); Medas (2003b); (2018); Uggeri (1987); (1990); (1998).

³ See Edgeworth (2011); Franconi (2016); (2017b); and Izdebski et al. (2016), for criticisms on prior approaches to river studies in classical scholarship.

⁴ While the scale of Roman interventions set them apart from previous periods, anthropogenic changes to the landscape had been underway since the Neolithic, with the Bronze Age Terramare culture being the first to attempt interventions aimed at water management in the region (Cremaschi et al. (2016); (2018); Mozzi et al. (2010); Starnini et al. (2018)).

2.1 Topography and Climate

Northern Italy is a geographically diverse region, containing environments that range from the low-lying wetlands of the Adriatic littoral to the snow-capped mountains of the Alps.⁵ A range of geological and hydrological processes served to create the region's landscape, which can be broken down into roughly three broad environments: the Alps, the Apennines, and the Po-Veneto plain.

2.1.1 The Alps

The northern and western limits of the study area are bounded by the Alps. The peaks average 1500 m a.s.l. in height (the highest, Mt. Blanc, reaches 4,808.73 m), with the Italian section of the range extending some 1200 km from western Liguria to the Balkans in the east.⁶ The height of the range exceeds the treeline, with vegetation changing from woodland, to grassland, to boulder fields at the highest altitudes.⁷

The Italian side of the range is home to several glaciers, including the Belvedere, Marmolada, and Miage, and glaciation has been an important mechanism in the formation of the recent Alpine landscape as one of its main erosional elements.⁸ The northern Alps and Alpine foothills are home to the great glacial lakes, the largest of which are Como, Garda, and Maggiore, while the remnants of glacial moraine amphitheatres, such as those on the Dora Baltea and Tagliamento rivers, serve to dominate the surrounding landscape.⁹ Numerous smaller moraine hills also act as a transition zone between the Alps and the valley floor.¹⁰ Wide, deep glacial valleys lead off the plain, their level floors offering easy access into the mountains and supporting human settlement. The largest of these, such as the Val d'Aosta and Val d'Adige, have formed important movement corridors for millennia, especially for the transhumance of livestock.¹¹ These valleys eventually lead to passes that offer access into Northern and Western Europe from Italy.

The modern Alpine climate can be described as cold-temperate. Temperatures in the winter are consistently below 3°C; those in the summer between 10 to 14.9°C.¹² The zone experiences heavy precipitation, with some of the peaks

⁵ Good discussions on the varied landscapes and individual geographic features present in the region are available in Agnoletti (2013) and Soldati and Marchetti (2017).

⁶ Fredi and Lupia Palmieri (2017), 40.

⁷ Fredi and Lupia Palmieri (2017), 40.

⁸ Bollati et al. (2017), 90-92; Fredi and Lupia Palmieri (2017), 44; Giardino et al. (2017).

⁹ Giardino et al. (2017), 80-81.

¹⁰ Biancotti (2001); Fredi and Lupia Palmieri (2017), 49.

¹¹ Gerling et al. (2017).

¹² Fratianni and Acquaotta (2017), 32-33.

experiencing over 3000 mm per year.¹³ The areas of highest altitude (normally above 3500 m a.s.l.) possess a nival climate, and are blanketed in perpetual snow and ice.

2.1.2 The Apennines

The southern edge of the study area is delimited by the Apennines, which form a barrier between the Po-Veneto plain, the rest of Italy, and the Ligurian Sea. Lower than the Alps, with the average height being 1200 m a.s.l., they still form a formidable obstacle. The majority of the range in Northern Italy falls below the tree line, with dense forest covering much of the higher slopes.¹⁴

The tectonic processes that led to the Apennines' formation have resulted in the chain having an asymmetrical profile. Mountains on the Ligurian and Tyrrhenian side of the range have short, steep slopes, while those that face the Po-Veneto plain have longer, gentler slopes.¹⁵ Water, rather than glaciation, has formed the main erosional element in the Apennines.¹⁶ The smooth and gentle slopes of the Apennine's north face have been formed by surface runoff, which itself has resulted in the selective erosion of the landscape.¹⁷ Narrow, steep sided stream valleys cut through the terrain, draining perpendicular to the range and running into the Po river network.¹⁸

The modern climate of the Apennines is classed as subcontinental-temperate, with zones of cool-temperate at the highest altitudes. In the modern period, mean temperatures in the winter months fall between 1 to 3.9°C; in the summer they fall between 16 to 19°C.¹⁹ In the areas of highest altitude, winter temperatures fall between 3 to 0°C, and between 15 to 19.9°C in the warmer months.²⁰

2.1.3 The Po-Veneto Plain

While the majority of the Po basin consists of the mountainous regions of the Alps and Apennines, the valley floor, or the *pianura Padana* as it is otherwise known, consists of a large plain that is enclosed by the Alps, Apennines, and the Adriatic. The plain varies between 100 and 80 km in width (roughly north-south), between the Alps and the Apennines and runs approximately 350 km, approximately east-

¹³ Fratianni and Acquaotta (2017), 30.

¹⁴ Ferrari (2017), 109.

¹⁵ Frepoli and Amato (1997); Fredi and Lupia Palmieri (2017), 52.

¹⁶ Some glaciation did occur, but to a far lesser extent and reduced impact on the landscape when compared to the Alps (Tellini (1994)).

¹⁷ Del Monte (2017); Vergari et al. (2013).

¹⁸ Pellegrini and Vercesi (2017).

¹⁹ Ferrari (2017), 110; Fratianni and Acquaotta (2017), 32.

²⁰ Ferrari (2017), 110; Fratianni and Acquaotta (2017), 32.

west, from the Adriatic to the foothills of the Alps.²¹ Although mainly comprised of flat, open country, the Po valley also contains several small groups of hills. In the west of the plain, the Colline del Po, Monteferrato, Roero, and Langhe Hills rise up, forming an undulating landscape that separates the extreme south-western reaches of the basin from the main plain (see Figure 2.2).²² To the east, the Berici and Euganean Hills form a transition zone between the Po and Veneto plains, remnants of sub-volcanic reliefs that were exposed via erosion.²³

The Po plain forms part of a massive foreland basin between the fold-and-thrust belts of the Alps and Apennines, a system of deeply buried canyons left over from the collision of the African and Eurasian plates that extends out into the Adriatic. Over the past 5-7 million years, this basin has slowly filled with marine and fluvial sediment, forming a layer 8 km thick in some places.²⁴ Adjacent to the Po plain is the *pianura Veneto*, distinguished by the watersheds of their respective river systems. While the Po valley and the Veneto plain are partially separated by the Berici and Euganean Hills, these do not form a continuous barrier. Consequently, movement between the two areas is near seamless and they are often referred together as the Po-Veneto plain. Combined, they cover 46,000 km², constituting 71% of all plain landscapes in Italy, yet only 15% of Italian territory.²⁵

The physical landscape of the plain is deeply affected by the varied fluvial contexts and geomorphology of the rivers that flow through it. The transition from the Alps and Apennines to the plain of the valley floor is dominated by raised alluvial fans dating from the late Pleistocene and early Holocene (see Figure 2.3).²⁶ The aggradation of these fans ended in the middle Holocene, at which point rivers and streams began to entrench into them. The alluvial fans and foothills form a transitional piedmont zone between the mountains and the plain. Stretching out beyond these is the flood plain itself, which is criss-crossed by fluvial ridges, some active, some abandoned, which meander out towards the path of the Po. The result is a landscape of gently undulating, shallow ridges.

²¹ Marchetti (2002), 362.

²² These hills were likely formed as result of the upthrust of the basin during the Oligocene and Burdigalian epochs (Faletti et al. (1995); Tiranti et al. (2013), 121-23).

²³ Fredi and Lupia Palmieri (2017), 50.

²⁴ Bosellini (2017), 23; Bruno et al. (2018); Gasperi (2001); Po River Basin Authority (2006), 23. In the Quaternary period, the valley formed a large marine basin that reached as far as Piedmont.

²⁵ Marchetti (2002), 361. The region is one of the most heavily populated and urbanised areas of modern Italy. The Po basin alone has over 3,210 recorded settlements in the modern period which contain an estimated 30% of Italy's population (Po River Basin Authority (2006), 12, 47).

²⁶ Cremaschi et al. (2018), 53-55. The Veneto plain along the Northern Adriatic coast is comprised almost entirely of several large alluvial 'megafans', most notably the Brenta megafan, the Nervesa megafan, and the Tagliamento megafan (Fontana et al. (2008); Mozzi et al. (2010)).

Depressed areas of backswamp are located between the alluvial fans and ridges, characterised by poorly drained, waterlogged soils of fine sediment and clay.²⁷ This makes them common hosts to marshland and riparian forest. In the areas closest to the Adriatic coast, the height of the land falls below sea level in several areas, resulting in waterlogged areas of brackish water and marsh, alongside the formation of lagoons.

The modern climate of the plain is classed as continental-temperate, and is particularly affected by the topography of the mountain ranges that surround it. The Alps create a barrier to the colder winds of Northern Europe, while the Apennines reduce the warming effect of the Ligurian Sea.²⁸ This results in a somewhat humid climate and although the plain currently experiences low rainfall, between 600-800 mm per annum, it was far wetter in the past (see below).²⁹ Mean temperatures in the winter months fall between 1.5 to 3°C; in the summer they fall between 9.5 to 25°C.³⁰

2.2 The Hydrology of the Po-Veneto River Network

Just as Northern Italy is home to diverse geography, so too does it possess diverse hydrology. A multitude of fluvial contexts are present across the region and the high volume of water has resulted in the presence of an extensive river network, fed by runoff from the mountains, lakes, springs, swamps, and drainage works.³¹ Its rivers range in size from small, seasonal mountain torrents, to larger streams and rivers with discharges of thousands of cubic meters per second, the Po forming the centre of the network.

With a length of 650 km, the Po is the longest river in Italy (see Figure 2.4).³² Originating at Monviso in the Cottian Alps, the Po descends through the Pian del Reo and onto the valley floor, exhibiting a mainly torrential regime in its upper course. Passing through Turin, the river curves east around the Colline del Po, before being swelled by the waters of the Dora Baltea as the plain begins to open up. The Po then makes its way across a wide flood plain, growing in size

²⁷ Brandolini and Cremaschi (2018), 42.

²⁸ Vezzoli et al. (2015), 347.

²⁹ Brandolini and Carrer (2021), 512; Fratianni and Acquotta (2017), 30. Although overall rainfall is low, precipitation normally occurs in intense downpours.

³⁰ Fratianni and Acquotta (2017), 32.

³¹ These formed defining landscape features in antiquity, with Strabo (5.1.5) describing the entire region as having been ‘filled with rivers and marshes’.

³² The upper Po runs from its source on the Pian del Re to the river’s confluence with the Dora Baltea. The middle Po runs from the Dora Baltea to its confluence with the Oglio. The lower Po runs from the Oglio to the Adriatic.

River	Length	Mean Discharge (m ³ /s)	Basin Size (km ²)
Po	650	1540	74,000
Adda	313	187	7979
Oglio	280	130	6649
Tanaro	276	123	8234
Ticino	248	330	7228
Mincio	194	60	2859
Secchia	172	42	2292
Dora Baltea	168	96	3890
Panaro	148	37	2292
Sesia	139	70	3037
Lambro	130	6	1685
Dora Riparia	125	25	1231
Trebbia	118	40	1150
Scrivia	117	19	1145

Table 2.1: Length, mean discharge, and basin size of the fourteen largest rivers in the Po basin (Po River Basin Authority (2006); Gumiero et al. (2009)).

and volume the further east it gets. When it reaches the delta region, it splits into five channels, the Po di Pila, Po di Tolle, Po di Maistra, Po di Levante and Po di Gnocca, before flowing out into the Adriatic Sea. The basin currently has a watershed of 74,000 km², draining the Southern Alps and Northern Apennines, alongside the Colline del Po, the Langhe, and Monferrato hills. In the modern period it has 141 tributaries of varying size, the largest being the Adda and the Oglio (see Table 2.1). Water forms an integral part of Northern Italy’s landscape, and in the modern era, the Po, its tributaries, and canals within the basin have a combined length of 6,750 km.³³

The Po is fed by tributaries originating from both the Alps and the Apennines, with its network influenced by their separate discharge regimes.³⁴ The regimes of Alpine rivers are driven by temperature, resulting in maximum discharge occurring during the spring and summer from snowmelt, coupled with a dry winter period characterised by low flow due to water being locked up as snow and ice.³⁵ The regime of Apennine rivers are driven by precipitation, resulting in two maxima, one in spring/summer, and the other in autumn. This causes periods of low flow during the summer, with the potential for drought in severe

³³ Gumiero et al. (2009), 481.

³⁴ Page (2021), 6. The valley’s drainage basin is asymmetric, with the Alpine tributaries being longer and discharging more water into the Po (Fredri and Lupia Palmieri (2017), 48).

³⁵ Benito et al. (2015), 17-18; Gumiero et al. (2009), 480; Nelson (1970), 155; Vezzoli et al. (2015), 347. The large glacial lakes located in the Southern Alps also help to regulate this regime.

cases (see Figure 2.5).³⁶ Seasonal flooding is a common occurrence on the Po during the spring and autumn, but it is often when high water levels from the Alpine and Apennine tributaries coincide that exceptional flooding occurs in the middle and lower Po.³⁷ The high volume of runoff and large number of tributaries has resulted in the Po having one of the largest discharge rates in Europe. Its mean annual discharge is 1,540 m³/s, although the greatest recorded discharge is 10,300 m³/s.³⁸

The rivers under consideration in this thesis are not solely limited to the Po and its tributaries. The Veneto plain contains numerous watercourses which flow out into the Adriatic or the Northern Adriatic lagoon system. While many rivers of the Veneto plain, such as the Bacchiglione and Brenta, possessed similar characteristics to those of the Po valley, several watercourses present significantly different fluvial geomorphology.³⁹ Most notable of these is the River Tagliamento, which has a length of 178 km and a drainage basin of 2580 km².⁴⁰ Braiding forms the Tagliamento's dominant morphology, with the river forming multiple intersecting channels (anabranches) separated by sandbars (see Figure 2.6).⁴¹ In a braided river, periods of high flow can lead to rapid changes in channel path, alongside sandbar formation and destruction, making this morphology highly unstable.⁴² During low flows, the majority of the channel remains dry with water contained within the anabranches. Roman intervention would connect the rivers of the Veneto plain to the Po basin, either through canalisation or channel diversion (see Section 3.1.2). Natural processes of erosion and deposition have also served to change the routes and watercourses. Indeed, the Adige and Reno rivers were tributaries of the Po during antiquity.⁴³ Consequently, the rivers of the Veneto plain and the Po basin should be viewed as part of a single network from a navigational and economic perspective during the Roman period (see Table 2.2).

³⁶ Gumiero et al. (2009), 481.

³⁷ Camuffo and Enzi (1996); Marchi et al. (1995), 477.

³⁸ Gumiero et al. (2009), 474. The discharge of 10,300 m³/s was recorded at Pontelagoscuro during the 1951 flood. The Po's shallow gradient (at times <1% in its lower reaches), normally helps to reduce the rate of discharge (Mozzi et al. (2020), 81).

³⁹ Page (2021), 5.

⁴⁰ Significant braiding is also seen in the middle Brenta and the Piave rivers, alongside the Torrente Meduna (Carton et al. (2009); Picco et al. (2013)).

⁴¹ Surian and Fontana (2017), 158-59.

⁴² Surian and Fontana (2017), 158-59.

⁴³ Calzolari (2004), 19-20; Mozzi et al. (2020), 83. The Adige is recorded as a tributary in several ancient sources, including Pliny, *Natural History*, 3.121; Servius, *Vergilii Aeneidem commentarii* 9.676; and Sidonius Apollinaris, *Epistulae* 1.5.4. Several possible paleochannels of the Adige have been identified, and it seems likely that a branch of the Adige entered the Po near Rovigo (Uggeri (2016), 85).

River	Length (km)	Mean Discharge (m ³ /s)	Basin Size (km ²)
Adige	410	235	12,100
Piave	220	137	4126
Reno	212	95	5965
Tagliamento	178	77	2916
Brenta	174	93	2300
Bacchiglione	118	30	1400
Livenza	112	85	2221
Sile	90	27	628

Table 2.2: Length, mean discharge, and basin size of other significant rivers within the Po-Veneto plain (Gumiero et al. (2009)).

2.2.1 The Evolution of the Po River Network

Rivers are constantly evolving landscape features, with the force of the current eroding its banks and bed, whilst simultaneously depositing sediment elsewhere. The Po river network is no different, and the course of its waterways have altered significantly since the Roman period. Changes to the river’s course were commented on in Antiquity and could often cause problems.⁴⁴ Several writers record incidents of the Po moving its path, and the property disputes this often caused as a result of the land created and lost on either side of the channel.⁴⁵ Ennodius described the Po as giving land to one ‘that it steals from another’ and Lucan records that after a flood, ‘some owners their land deserts, while others gain new acres by the river’s gift’.⁴⁶ Since the Roman period, meanders have formed and broken, and channels have been created and dried up again. The river itself has moved progressively northwards, and riverbed aggradation (an increase in the elevation of the riverbed due to the deposition of sediment), has raised the height of the channel and floodplain.⁴⁷

In addition to naturally occurring changes or indirect anthropogenic impacts, the river network in the Po-Veneto plain has seen extensive direct human alteration throughout its history. The effects of natural changes in a hydrological system can be exacerbated by human intervention, whose alterations to the river network can have unforeseen consequences. Intervention began during the Roman period, and before the nineteenth century, alterations to the river network princi-

⁴⁴ Movement of the Po in antiquity is seen at Adria, where the main channel of the river dried up and shifted further south. The Tartaro river subsequently occupying the abandoned channel (Corrò and Mozzi (2017), 490; Piovan et al. (2006)).

⁴⁵ Bannon (2020). Campbell (2012), Chapter 3, contains a wide discussion on rivers in Roman law and how changes could affect ownership of property. See also Hyginus Gromaticus, *De generibus controversiarum* 87-88 for specific rulings in relation to the Po.

⁴⁶ Ennodius, *Vita Epiphani* 21-22; Lucan, *Pharsalia* 6.272-278.

⁴⁷ Veggiani (1974); Uggeri (1990), 179.

pally consisted of channelisation and diversion to help regulate flow and provide water for irrigation.⁴⁸ Major works included the construction of navigation canals in the twelfth century and the rerouting of the mouth of the Po, first by the Ferrarans in 1150 in an attempt to save the city's port, and then by the Venetian Republic in 1604 to avoid the silting up of the lagoon.⁴⁹ A major network of embankments was also constructed along the length of the middle and lower courses of the river.⁵⁰ However, it is only within the last century that major human activity has caused widespread changes to the river's regime along the entirety of its course, as the potential of the river network was realised in the industrial age. The Po and its tributaries have seen the construction of significant infrastructure either within or directly adjacent to the river channel, with approximately 7,000 sanctioned hydroelectric projects having been constructed since the start of the twentieth century.⁵¹ Numerous weirs, especially in the upper courses, have been constructed as part of flood control measurements. Bridges and barrages have influenced river flow, retaining water and altering currents. Increasing urbanisation has also resulted in the channelling and diverting of waterways in proximity to these spaces in order to protect lives and property.

One of the most disruptive activities has been gravel and sand extraction from the riverbed. This was especially prominent during the 1960s and 70s and had unforeseen consequences. The Po has always carried a heavy sediment load, but a combination of sediment mining and the construction of weirs and dams along its length caused a decrease in sediment volume by approximately 38% over the second half of the twentieth century.⁵² The catching or extraction of sediment has resulted in the channels of the Po and its southern tributaries moving from aggradation to degradation (a decrease in the elevation of the riverbed due to erosional processes).⁵³ This has resulted in a lowering of the channel in large stretches of the middle and lower river, often by as much as 4 m, and the undercutting of bankside infrastructure.⁵⁴ Consequently, Northern Italy's modern river network bears little resemblance to that of the Roman period. To create a model of behaviour for the ancient river network, it is necessary to consult a combination of ancient literature and paleo-hydrological and geomorphological evidence.

⁴⁸ Surian and Rinaldi (2003), 308. See Page (2021) for a summary of Roman interventions along the riverbanks.

⁴⁹ Bondesan et al. (1995); Nelson (1970), 165; Simeoni and Corbau (2009).

⁵⁰ Marchi et al. (1995), 476; Mozzi et al. (2020), 81.

⁵¹ Gumiero et al. (2009), 481. These are principally within the Alpine reaches of the basin.

⁵² Surian and Rinaldi (2003), 316.

⁵³ Marchetti (2002), 370. At one point the level of extraction was so great that the Po delta stopped prograding due to the lack of sediment (Ninfo et al. (2018)).

⁵⁴ Surian and Rinaldi (2003), 317.

2.2.2 Ancient Writers on the Po River Network

Considering the extensive changes the water network has undergone since the Roman period, reconstructions are reliant on other sources of evidence. Although there are no complete records of the route and characteristics of the Po in antiquity, the river is mentioned in several ancient geographic texts such as Strabo's *Geography* and Pliny's *Natural Histories*. The Po and its tributaries also appear in several historical works, such as those of Polybius, Livy, Tacitus, and Procopius, and have formed the setting for more literary writing, with Virgil and Lucian both including the Po in their poetry and satire. This corpus of work offers a glimpse into aspects of the region's rivers, which can be combined to create a more complete reconstruction of its water network.

In some aspects, the modern Po shares the same characteristics as the ancient river. The Po, like all rivers, varied substantially along its length and in its source regions, the Po had torrential qualities, characterised by seasonal periods of high and low water flow. Pomponius Mela described the flow in its upper course as 'scant and meagre', and Pliny claimed the river's source would dry up under 'the midday summer sun'.⁵⁵ As the Po continued downstream its volume was swelled by the addition of multiple tributaries, so by the time it reached Turin it was navigable, according to Polybius (second century BC) and Pliny (first century AD).⁵⁶ Beyond Turin, the river continued to grow, and at its confluence with the Dora Baltea, in the vicinity of the town of Industria, it began to become 'particularly deep'.⁵⁷ By the time it reached the plain proper, no longer confined between the Colle di Turin and the Alps, the river seems to have widened. Virgil claimed no other river flowed with a 'mightier force' and the large volume of the river was commented on in antiquity by several authors: Pliny observed that no 'other river increases so much in volume in so short a distance', while Livy stated that the 'strong current' made the river unfordable in some of its upper sections near the confluence of the Po and the Ticino.⁵⁸ Strabo described the river as 'large and swift,' though as it descended from its upper course and onto the plains, it became 'larger and more gentle in its flow'.⁵⁹ He observed that the great number of tributaries increased the volume of water in the river, causing 'the stream to widen out in the plain' and resulted in 'the force of its current being dispersed and blunted'.⁶⁰ In the river's middle section, its wide meanders, still a characteristic of the modern river despite attempts at channelisation, are

⁵⁵ Pliny, *Natural History* 2.106; Pomponius Mela, *Chorographia* 2.62.

⁵⁶ Pliny, *Natural History* 3.123; Polybius, 2.16.

⁵⁷ Pliny, *Natural History* 3.123.

⁵⁸ Livy, 21.47; Pliny, *Natural History* 3.119; Virgil, *Georgics* 4.373-74.

⁵⁹ Strabo, 4.6.5.

⁶⁰ Strabo, 4.6.5.

commented on by Pliny, who says they added ‘eighty-eight miles’ to the length of the river.⁶¹ Aside from the Po, the variety the regimes of its tributaries are commented on by other ancient writers. Sidonius Apollinaris, writing in the fifth century AD, records a journey he took down the Po from Pavia. During his voyage, he took the opportunity to explore several of the major tributaries of the Po, in particular, ‘the sedgy Lambro, the blue Adda, the swift Adige, and the sluggish Mincio’.⁶²

The lower Po, in particular the delta region, has changed extensively since the Roman period. The ancient coastline has prograded into the Adriatic by 7 km in some places, and the mouth of the Po has moved steadily northwards.⁶³ Although land drainage schemes were extensive (see below), they did not cover the entirety of the plain. Large areas of marsh and open water remained, particularly around the delta and the coast. The Adriatic lagoon system was once far more extensive, and likely stretched the entirety of the way to Ravenna (see Figure 2.7).⁶⁴ Indeed, Strabo recalls that the ‘greater part of the (lower) plain is made full of lagoons . . . and while some parts have been relieved by drainage and are being tilled, others afford voyages across their waters’.⁶⁵ During Antiquity, the Po emptied into the Adriatic through seven mouths, the channel beginning to diverge shortly after the river passed through Hostilia. These seven mouths and extensive adjacent lagoon system resulted in the coastal area being referred to as the Seven Seas.⁶⁶ The most southerly mouth and the one closest to Ravenna was called the Padusa, formally known as the Eridanus or the Spineticus due to its proximity to the former Etruscan city of Spina.⁶⁷ The next mouth was the Caprasian, then the Sagis, and then Volane. Further to the north were the mouths of Carbonaria and the Fossiones and the Philistina. The paths of these branches have been heavily debated amongst Italian archaeologists, and whilst there is little agreement for their precise locations, a rough reconstruction of the delta area in the Roman period can be made (see Figure 2.8).⁶⁸ Out of the seven mouths, only the Padusa, Carbonaria, the Fossiones, and the Philistina were

⁶¹ Pliny, *Natural History* 3.118. Ennodius (*Vita Epiphani* 2.1) also mentions the meanders around Pavia.

⁶² Sidonius Apollinaris, *Epistulae* 1.5.4. Many of these characteristics are still exhibited by these rivers in the modern period (Gumiero et al. (2009)).

⁶³ The evolution of the delta and Adriatic coastline have been well documented using a combination of aerial and satellite photography, LiDAR scans, and sediment coring. See Stefani (2017) for a concise history of the region’s coastal evolution.

⁶⁴ Marchiori (1990), 197-98; Uggeri (1990), 176-77.

⁶⁵ Strabo, 5.1.5.

⁶⁶ Herodian, 8.7; Pliny, *Natural History* 3.119; Pomponius Mela, *de Situ Orbis Libri* 3.2.62.

⁶⁷ Pliny, *Natural History* 3.120.

⁶⁸ Bosio (1979); Calzolari (2007); Uggeri (1978); (2016). Numerous paleochannels of the Po have been identified through LiDAR, coring, and aerial survey, but it is difficult to establish a precise chronology of when they were active.

considered to be deep-water and accessible to large vessels.⁶⁹

One element of the river that seems to have captured the imagination of ancient writers is the Po's reputation for regular, and at times violent, flooding. Pliny states flooding was a common occurrence, though not without its benefits, as the alluvium left by the receding waters 'bestowed bounteous fertility'.⁷⁰ However, it is important to differentiate between the annual floods – expected and necessary to ensure the continued deposition of this fertile alluvium – and the rare and exceptional large-scale flood events which had a serious impact on lives and property. Virgil, a native of the region, paints a picture of an extreme flood on the Po in his *Georgics*, where the river carries 'whole forests along in the swirl of his frenzied current, carrying with him over the plain cattle and stalls alike'.⁷¹ As stated above, the Po river network has two points of peak flow, in the spring and the autumn, the times at which the risk of flooding in the region was at its highest. This is seen when Tacitus records, in a somewhat matter of fact way, that during the October/November of AD 69, Flavian troops, marching to fight the Vitellians at Cremona, were forced to travel lightly because 'the plains were inundated by the Po'.⁷² Martianus Capella, writing in the fifth century AD, also records that 'when the snows of the Alps have melted, due to the heat of the summer sun, it (the Po) swells beyond its banks'.⁷³ Of course, flooding represents one end of the spectrum of extreme hydrological conditions. At the other are periods of low flow, where the volume of water in sections of the river might be severely reduced or dry up altogether. These could be equally devastating as floods, as lives and livelihoods often depended on the regular flow of the river for its resources, navigation, or irrigation. Low flows are harder to track than flood events, as they do not leave the same traces in the archaeological record, nor do they capture the minds of writers in the same way that the excessive destruction of a flood might.⁷⁴

⁶⁹ Pliny, *Natural History* 3.121.

⁷⁰ Pliny, *Natural History* 3.119.

⁷¹ Virgil, *Georgics* 1.481-83.

⁷² Tacitus, *Histories* 3.50.

⁷³ Martianus Capella, *De Nuptiis Philologiae et Mercurii* 6.640.

⁷⁴ The first recorded incident of a period of low water levels on the Po comes from Procopius (*History of the Wars* 6.28.3-5) during the sixth century. He recounts an incident in AD 539 where the Goths had loaded a great number of boats on the upper Po with grain and other supplies, with the intention of sailing downstream to assault Ravenna. However, as they attempted the journey, water levels in the river fell to such an extent that navigation was impossible. While the Gothic vessels were stuck, the Romans took the opportunity to capture them and their cargoes. Interestingly, Procopius records that 'as far as we know from tradition, this had never happened to the river before', suggesting that water levels in the river had previously remained relatively consistent from year to year, or at least reliably deep enough to allow navigation. Tacitus (*Histories* 4.26) records a similar incident on the Rhine frontier where a Roman cargo vessel stranded by low water levels became easy pickings for soldiers on the far side of the river. It is possible the low water conditions seen on the Po were a result of the dust veil caused by

2.2.3 The Paleohydrological and Paleoclimatological Evidence

Changing climate has played a large part in the evolution of the Po-Veneto water network.⁷⁵ Fluvial systems are highly susceptible to even minor variations in temperature and precipitation, which can have a major impact on their behaviour. An increase of 1°C can reduce river flow by between 5 and 15% due to decreased precipitation and evapotranspiration.⁷⁶ This increases the threat of winter flooding and summer drought. Alternatively, a decrease of 1°C will increase precipitation throughout the year, increasing the risk of flooding year-round and reducing the likelihood of summer droughts. These changes in temperature can also affect the form the river takes.⁷⁷ Low precipitation means less sediment is carried in suspension, resulting in a river that is more prone to forming meanders. Conversely, high precipitation means a higher sediment load, increasing the potential for river channels to braid and obstacles such as sandbars and islands to form. These changes could have major implications for those living in proximity to rivers, affecting everything from bankside infrastructure, regional agriculture, and the navigational capacity of the river system.

The publication of several major palaeoclimatic studies in Northern Europe over the past decade has allowed detailed reconstruction of weather conditions and riparian environments during the Roman period.⁷⁸ Unfortunately, palaeoclimatic data for this era exist at a much lower level of resolution for Italy, but several recent studies suggest there was extensive regional variation across the peninsula.⁷⁹ For example, speleothems from Apennine caves suggest prolonged dry periods during the first and second centuries AD in Central Italy, in contrast to the supposed uniform wetness theorised by the model of the Roman Climatic Optimum.⁸⁰ Excavation and geomorphological research within Northern Italy

volcanic eruptions in AD 536 and AD 540 (Sigl et al. (2015), 557-48). A consequence of the veil would have been reduced rainfall, and (crucially for the Po's alpine tributaries), reduced snow-melt because of cooling, both leading to lower water levels in the river.

⁷⁵ Page (2021), 3-7.

⁷⁶ Bravard (2008), 55; Franconi (2013), 709; (2016), 34-35; Klostermann (2001), 37-38.

⁷⁷ Franconi (2013), 709; (2017b), 8-9; Klostermann (2001), 39-45; Macklin et al. (2012), 2146.

⁷⁸ See Büntgen et al. (2011); Harper (2017), 44-45; Harper and McCormick (2018), 33-39; McCormick et al. (2012); Shindell et al. (2003); Sigl et al. (2015). These are complimented by more targeted studies that can reconstruct local climate in detail.

⁷⁹ Bini et al. (2020), 791; Finné et al. (2019), 858-59; Labuhn et al. (2016), 74-81.

⁸⁰ Bini et al. (2020), 800. Proponents of the Roman Climatic Optimum model suggest that from c. 200 BC until c. AD 250, the climate of North-Western Europe was relatively stable, with precipitation fluctuating between narrow margins (Shindell et al. (2003); Sigl et al. (2015); Harper (2017)). This period of warm, wet climate coincided with Rome's expansion across the Mediterranean. The last quarter of this period, roughly between AD 150 and AD 250, would begin to see a transition, and the following period (AD 250-550), was characterised by extensive variability, culminating in the Late Antique Little Ice Age of the sixth and seventh centuries AD

point to increasing hydrological instability in the region from the third century onwards, its climate becoming increasingly wet.⁸¹

Evidence of a changing climate from the third century onwards is further reflected in archaeological evidence from the Po-Veneto plain.⁸² The Po's Apennine tributaries seem to have changed towards the end of the third century AD, becoming more violent and unpredictable. Stratigraphic cores taken from Bologna, Modena, and Reggio Emilia document a series of large flood deposits, with all but one occurring between the third and the sixth centuries.⁸³ Furthermore, flooding led to a large increase in land elevation in some areas of the plain. For example, alluvium deposited by a flood in the latter half of the first century AD in Modena raised the ground level of the eastern town by 32 cm, however between the third and sixth centuries, four separate flood events would raise the level by a total of 2.6 meters.⁸⁴ The increasing frequency of large scale flood events had serious consequences for the town. Modena was built on marshy land that relied on drainage canals to maintain its habitability and, as flooding increased, these artificial channels were ill prepared to deal with the new volume of water.⁸⁵ Excavation exposed the remains of *domus* located inside the city walls that had been abandoned and demolished in the aftermath a major flood during the fourth century.⁸⁶ In Modena's hinterland, pollen analysis undertaken on the samples from the cores produced evidence that flooding changed the landscape around the city. After the third-century flood, taxa associated with stagnant water dominated samples, suggesting the creation of wetlands.⁸⁷ This new, waterlogged environment would persist until at least the end of the sixth century. Elsewhere, in Bologna, riverbed aggradation (an increase in the elevation of the riverbed due to the deposition of sediment) seems to have begun across the river network during the third century AD and has continued to the present day.⁸⁸ Consequently, in some areas, the modern elevation of the bed of the Reno is 12

(Harper (2017), 44-45; Harper and McCormick (2018), 33-39). The Roman Climatic Optimum narrative has been challenged by Haldon et al. (2018).

⁸¹ Labuhn et al. (2016), 74-81. Squatriti (2010), 816-18, notes geographical variation for the severity of flooding in the Late Antique Po-Veneto plain.

⁸² Page (2021), 3-7.

⁸³ Bosi et al. (2018), 4-5; Cremonini et al. (2013), 170-73; Cremaschi et al. (2018), 59-60. The floods here are considered exceptional events, as opposed to the smaller annual floods common in the region. Speleothem analysis from Renella cave in the Apuan Alps also points to a significant increase in flooding in Northern and Central Italy during the sixth century AD (Zanchetta et al. (2021)).

⁸⁴ Bosi et al. (2018), 4-5.

⁸⁵ Brogiolo (2015), 54.

⁸⁶ Bosi et al. (2018), 13.

⁸⁷ Bosi et al. (2018), 11-12. A similar scenario seems to have taken place in the countryside between Reggio Emilia, Parma, and the Po during the sixth century (Brandolini and Cremaschi (2018), 3; Brandolini and Carrer (2021), 512, 521).

⁸⁸ Cremonini et al. (2013), 171.

m above Roman levels. Changes were also exacerbated by the intense soil erosion caused by deforestation and intensive agriculture within the Po plain during the Roman period.⁸⁹

In many cases, settlement showed resilience to the effects of flooding and continuity of habitation is visible in the archaeological record.⁹⁰ At the sites of Riva del Garda in Trento, and Strevi in Piedmont, there is evidence for multiple phases of flooding from the first century AD onwards, the aftermath of which saw the rebuilding of the settlements at a new occupation level each time.⁹¹ In the west of the Po-Veneto plain, in Piedmont, there is evidence for several instances of flooding at the rural site of San Giorgio Canavese, where it seems efforts were made to remove the deposit of alluvium left by a second century AD flood.⁹² The deposit only survived in small sections of the open area in front of the main structure. The risk of flooding may also have affected site choice in some cases, with many settlements located on higher ground such as alluvial terraces, which put them above the flood plain.⁹³ However, from the third century onwards, the impact of flooding seems to have become more devastating to the communities it affected.⁹⁴ The degradation of infrastructure used to manage and control the water network, combined with the challenges posed by the socio-economic upheaval of Late Antiquity, served to reduce the resilience of settlements when faced with natural disaster.⁹⁵ At Modena, the sequence of floods explained above between the third and sixth centuries contributed to the demise of the town and led to a relocation of the urban centre to less vulnerable ground.⁹⁶ Similar

⁸⁹ Marchetti (2002), 367; Stefani (2017), 196-97. Across the central plain, most soils show truncated argillic horizons and sediment cores demonstrate that the Po delta started to rapidly prograde during this period. Indeed, during the late first century BC, Strabo (5.1.5) describes the mouth of the Po as being 'choked with mud', reflecting its high sediment load.

⁹⁰ Page (2021), 20-21.

⁹¹ Bassetti et al. (2013), 38-44; Quercia et al. (2015), 144.

⁹² Ratto and Crivello (2014), 25. The deposit only survived in small sections of the open area in front of the main structure which saw continued use until the third century.

⁹³ Cera (1995), 183; Dall'Aglio et al. (2012). This was true for the most part, although there are several examples of cities such as Acqui Terme and Pavia which were partially constructed in the paleochannels of rivers and thus were more prone to flooding (Crosetto (2013b), 76-77).

⁹⁴ In Late Antiquity, written records of extreme flooding become more common, though as to whether this is due to an actual increase in hydrological events or a greater focus on Northern Italy and natural phenomena in the literature is hard to say (Christie (2006), 200; Squatriti (2010), 823-24). The most famous flood event of the period was the 'Paul the Deacon Flood' of AD 589, in which Paul (*History of the Lombards* 3.23-4) described a 'deluge of water in the territories of Venetia and Liguria, and in other regions of Italy' that destroyed many 'estates and seats' alongside a great number of 'men and animals'. Floods on the Po feature prominently in religious literature from the post-Roman period, however, these may reflect a wider trend in using extreme hydrological events, such as floods and droughts, allegorically to represent political and social upheaval, rather than 'real' incidents (Squatriti (2010), 807-09, 821-23; Cremonini et al. (2013), 175).

⁹⁵ Page (2021), 3-7.

⁹⁶ Bosi et al. (2018), 13; Brogiolo (2015), 54.

outcomes can be seen at Acqui Terme in Piedmont, where increased flooding saw the abandonment of the areas closest to the watercourse and a relocation to higher ground in the late third-early fourth century.⁹⁷ In the Venetian plain, flooding and sediment deposition contributed to the decline of cities such as Altinum, Adria, Este, and Julia Concordia during this period, where severe flood damage, the silting up or movement of the economically important river channels, and additional socio-economic pressures, proved irrecoverable.⁹⁸

2.3 The Human Landscape

Despite the hydrological risks presented by its rivers, an abundance of level ground, fertile soil, and water has made the Po-Veneto plain an attractive area for human habitation for millennia. The arrival of humans in Northern Italy saw the beginnings of landscape reorganisation, yet it would not be until the Roman period that large-scale alteration and exploitation of the landscape took place. By the Bronze Age, the area had already been heavily deforested, and by the Roman period, almost 60% of the region's tree cover had disappeared, mainly confined to mountainsides or riparian forests.⁹⁹ In tandem with this large-scale land clearance, the Po-Veneto plain underwent territorial reorganisation in the form of centuriation, and the beginnings of intensive agriculture. As discussed above, water formed an integral part of the landscape of the Po plain, a fact that is true in both the ancient and the modern periods. The presence of the Alps and Apennines account for the high volume of water in the region and the extensive runoff from these two mountain ranges, coupled with the low lying valley floor, results in a higher than average water table. Although important for agriculture and transport, communities within Northern Italy would try to manage water, both to reduce hydrological risk and to expand the availability of arable land in the waterlogged zones.

⁹⁷ Crosetto (2013b), 76-77.

⁹⁸ Boscolo (2015), 341-44; Brogiolo (2015), 58-59; Fontana et al. (2020).

⁹⁹ Palyenological studies from across the region show a decline in taxa from lowland forests which are replaced with taxa associated with grasslands and cereal crops (Caramiello et al. (2014a), 76-77; Caramiello et al. (2014b), 16-17; Cremaschi (2009), 36-37). Despite heavy deforestation, the region was renowned for its timber, particularly larch, which was brought down the Po to Ravenna. Its properties for construction, especially its fire resistance, were highly valued, with Vitruvius (*de Architectura* 2.9.16) lamenting in the late first century BC that there was no provision to transport it to Rome where such qualities were desperately needed.

2.3.1 Agriculture, Centuriation, and Land Reclamation

The micro-regional variation across Northern Italy supports a variety of agricultural practices, resulting in intensive farming in both the Roman and modern periods. The abundance of flat and fertile land across the Po-Venetian plain has been used for the cultivation of staple and non-staple crops, including wheat, fruit, and herbs.¹⁰⁰ The pre-Alpine areas are less fertile than the plain and remained heavily forested, however, the eastern pre-Alps and Apennine foothills in the piedmont zone saw more intensive cultivation higher up their slopes for olives and vines.¹⁰¹ When it came to the cultivation of food crops, the region was famed for its output. Polybius believed the Po-Veneto plain ‘surpassed in fertility any other in Europe’ and recorded that it produced ‘an abundance of corn’, alongside other crops such as panic, millet, and barley.¹⁰² He went so far as to say inn keeps would charge their guests a flat rate per head for dinner, rather than for what they ordered, because of the ‘cheapness and abundance’ of food in the region.¹⁰³ Varro claimed that pigs reared near Milan were so fat that they ‘cannot stand’, with both Polybius and Strabo stating that Rome was fed ‘mainly on the herds of swine’ that were reared in the region.¹⁰⁴ As for wine, Strabo implied that the region’s viticulture was so successful that it had to be stored in barrels ‘larger than houses’.¹⁰⁵

While the Roman period saw the widespread exploitation of the natural landscape, agricultural development was preceded by land reorganisation via centuriation (see Figure 2.9).¹⁰⁶ Traces of centuriation can still be found in modern field boundaries, roads, and drainage channels, especially in the vicinity of the former via Aemilia and in the Veneto plain north-east of Padua.¹⁰⁷ The centuriation schemes of the Po-Veneto plain fulfilled a dual purpose of land division and land reclamation. In an effort to adapt this environment to human needs, large-scale drainage has been carried out in the region since the Roman era. The first recorded intervention was undertaken by Marcus Aemilius Scaurus in the late second century BC, where it is recorded that he ‘drained the plains by running

¹⁰⁰ Po River Basin Authority (2006), 14; Bosi et al. (2011), 1629-30.

¹⁰¹ Po River Basin Authority (2006), 15.

¹⁰² Polybius, 2.15.

¹⁰³ Polybius, 2.15.

¹⁰⁴ Polybius, 2.15; Strabo, 5.1.12; Varro, *de re rustica* 2.4.11.

¹⁰⁵ Strabo, 5.1.12.

¹⁰⁶ Bosio (1984); Gabba (2001); Prenc (2002). See Muzzoli (2010) for a summary of the centuriation schemes present within Northern Italy, alongside associated bibliography.

¹⁰⁷ Po River Basin Authority (2006), 14. Some of the most extensive centuriation occurred along the axis of the via Aemilia where some of Rome’s earliest colonies in the region, Ariminum, Bologna, Modena, Parma, and Piacenza, were founded (Gabba (2001); Roncaglia (2018), 32-33).

navigable canals from the Padus as far as Parma'.¹⁰⁸ These interventions would steadily reduce the extent of the marshlands within the Po plain over the Roman period (although they persisted in the areas closest to the rivers).¹⁰⁹

Excavation and field survey have revealed the extent and impact that centuriation based drainage schemes had on the landscape. On the southern bank of the Po, extensive remains of drainage channels have been uncovered as part of the centuriation network between Modena and Piacenza along the line of the via Aemilia. Targeted excavation revealed that the roads of the grid were flanked by drainage channels that varied between 3 and 7 m, and were often 1-2 m deep.¹¹⁰ The size of these channels suggests they may have been navigable by small craft, serving as an alternate means of transport within the grid. Reconstructions of Modena's centuriation grid estimate it contained approximately 5000 km of ditches and canals, which eventually drained into the Po.¹¹¹ Field survey between Piacenza, Parma, and Reggio Emilia also shows the expansion of settlement into the territory closest to the river during the Roman period, with settlement patterns demonstrating a low regard for hydrological risk.¹¹² These newly reclaimed areas (often consisting of fine sediments) were less suitable for arable farming using Roman agricultural techniques, but may instead have been used for grazing.¹¹³

Drainage channels need regular maintenance to be effective. With the centuriated landscape in eastern Emilia-Romagna alone having 20,000 km of drainage channels, there was a substantial amount of infrastructure to maintain across the Po-Veneto plain.¹¹⁴ If neglected, drainage channels will fill with sediment, reducing capacity, or become blocked by debris, reducing flow. The blockage of only a few channels would be enough to compromise the system. Socio-economic and environmental pressures from the third century onwards probably made it increasingly difficult to maintain the complex network of drainage infrastructure required to protect the land.¹¹⁵ For example, during the fifth century backswamp areas between Reggio Emilia, Piacenza, and the Po, would reactivate and transform into two large marshes known as the Valle di Gualtieri and Valle di Novellara as drainage schemes from the Roman era began to fail.¹¹⁶ Field survey further

¹⁰⁸ Strabo 5.1.11.

¹⁰⁹ Brogiolo and Sarabia-Bautista (2017), 150-56; Sarabia-Bautista (2017), 83-85.

¹¹⁰ Botazzi (1992), 172-74; Botazzi and Labate (2017), 18.

¹¹¹ Botazzi and Labate (2017), 18-19. The excavation of these channels was a serious endeavour, with the network estimated to have taken at least 12,000 man-hours to complete.

¹¹² Brandolini and Carrer (2021), 221; Dall'Aglio and Marchetti (1991), 164.

¹¹³ Brandolini and Carrer (2021), 221; Bosi et al. (2015).

¹¹⁴ Cremonini and Mattioli (2017), 22.

¹¹⁵ Brogiolo (2015), 49-50; Curtis and Campopiano (2014), 95. Many Roman land divisions and drainage works have been discovered beneath deposits formed by the creation of wetlands.

¹¹⁶ Brandolini and Cremaschi (2018), 4-6. See also the example of Modena's hinterland discussed above, alongside the floodplain of the Bacchiglione north of Padua (Sarabia-Bautista (2017),

suggests a mass restructuring of the landscape in the post-Roman period, with rural settlement retreating to higher ground above inundation level.¹¹⁷ Pollen studies further suggest swamp and woodland returned as common landscape features of the landscape. In contrast to the Roman period, the region's Late Antique and Early Medieval shows high correlation with areas of low hydrological risk, suggesting this was an important factor in site placement.¹¹⁸

2.3.2 Responding to Hydrological Risk

In response to the region's low water table and the threat posed by flooding and channel avulsion, it is unsurprising that there were extensive Roman efforts to manage the threat posed by water in the region and protect riparian communities and landscapes.¹¹⁹ Some of the best recorded instances of defensive works come from the Veneto, in particular the areas around Este and Padua. On the course of the ancient Adige, evidence of an extensive series of Roman embankments have been discovered near in the vicinity of Este.¹²⁰ Situated along the river's paleochannel, they ran for at least 2 km in length between Saletto and Ospedaletto.¹²¹ They were substantial structures constructed on the banks of the river, possibly dating to the pre-Roman era in their original creation, but later reinforced with large blocks of locally quarried trachyte for increased durability during the Roman period (see Figure 2.10). The expense and scale of the work necessitated the involvement of public officials, reflected on two inscriptions referring to committees of *decuriae* responsible for the construction of embankments to stabilise the route of the Adige.¹²² These embankments would have been constructed at the same time as the centuriation grid around Este, and it seems likely that they were intended to prevent the movement of the river which could alter the structure of the territory.¹²³ In addition to protecting against

83-85).

¹¹⁷ Brandolini and Cremaschi (2018), 3; Brandolini and Carrer (2021), 212, 221; Dall'Aglio and Marchetti (1991), 164.

¹¹⁸ Brandolini and Cremaschi (2018), 7-10. Significant land reclamation would not begin again until the tenth century.

¹¹⁹ See Page (2021) for a discussion of responses to hydrological risks in the Po-Veneto plain during this period.

¹²⁰ The Adige originally had a more northerly course that took it closer to the Euganean Hills (Brogiolo and Sarabia-Bautista (2017); Zara (2018), 329-30). Embankments have also been discovered in Bologna, Piacenza, and Vicenza (Bruno et al. (2013), 1566; Marini Calvini (1985), 269, note 28; Mazzocchin and Furlan (2016); Ortalli (1993), 46-48). See also Cera (1995).

¹²¹ See Balista and Bianchin Citton (1987), 18; Balista et al. (2010), 141-48; Bianchin Citton and Balista (1991), 27-32; Bonetto and Busana (1998), 92.

¹²² CIL 5.2603. *Dec(uria) Clod(iana) cu/r(atoribus) Q(uinto) Nae/vio L(ucio) Sei/o pig(neratore) C(aio) A(ntesti/o) s(umma) h(ominum) / LXXXVIII / in sing(ulos) / h(omines) p(edes) XXVII / s(umma) op(eris) p(edes) / —(milia) CCC/XCVIII.*

¹²³ Boscolo (2015), 337-40; Zara (2018), 331-32.

channel movement, embankments could also serve to shield bankside infrastructure such as bridges from the threat of undercutting by the river.¹²⁴ Evidence for this exists in Padua, where excavations have revealed a wooden quayside that underwent continued maintenance from the second century AD onwards due to increased undermining and bank erosion from the River Bacchiglione.¹²⁵ Aside from providing river defences, embankments also had the potential to be used as towpaths, providing the continuous flat surface needed for those hauling a vessel.¹²⁶

While embankments were predominately used to stabilise and protect riverbanks from channel movement, dykes were utilised to protect areas from or raise infrastructure above the level of flooding. Both Strabo and Lucan refer to the Po as being ‘defended by dykes’ and the disastrous consequences of their failure on the surrounding landscape.¹²⁷ Few dykes survive, with many having been broken up for their material or to make way for agricultural expansion, however, one of the largest extant examples is the Arzeron della Regina to the north-east of Padua. Excavation of its surviving sections revealed that the Arzeron sat upon a foundation of Euganean trachyte interspersed with brick fragments, with the core of the structure being formed of compacted layers of clay and silt (see Figure 2.11).¹²⁸ The width of the trapezoidal structure varied between 30 and 36 m at its base, narrowing to 18 m at the top, which was crowned with a gravel road at a height of 4–4.5 m.¹²⁹ Given the Arzeron’s position running north–south parallel to the bank of the River Brenta over a distance of over 40 km, it was probably intended as a flood defence, protecting the land to the west of the dyke from inundation (see Figure 2.12). Other dykes, such as the Terraglione di Vigodarzere exhibit similar properties.¹³⁰ Where floodwaters could not be contained or ground sufficiently drained to create stable and reliable roads, the dykes were also used to elevate road surfaces, providing a stable foundation in marshy ground and keeping the roadway above the level of inundation. This is seen on the Via Annia, where the road ran atop an embankment for long stretches between Altinum and Aquileia.¹³¹ Tacitus also records that the Via Postumia ran atop a dyke

¹²⁴ This was especially important in a region characterised by loose, sandy soil that enabled swift channel erosion and movement (Marchetti (2002)).

¹²⁵ Balista and Ruta Serafini (1993), 98–101; Beltrame (2001), 442–43.

¹²⁶ Medas (2018), 157–58.

¹²⁷ Lucan, *Pharsalia* 6.272–278; Strabo, 5.1.5.

¹²⁸ Rosada and Bonetto (1995), 29 n. 96.

¹²⁹ Bonetto (1997), 34–44.

¹³⁰ Bonetto and Busana (1998), 89.

¹³¹ Basso et al. (2004), 57–9; Mateazzi (2009), 28; Papisca (2010). It was common for most dykes to host some sort of road surface, the structure providing a flat level surface for overland transport.

between Cremona and Hostilia.¹³² Elements of the structure survived until the first half of the twentieth century, with the dyke apparently rising to a height of 2 m and being 20 m wide at its base.¹³³ The variety and scale of the infrastructure outlined above reflects the lengths Roman communities in Northern Italy went to in order shape the natural environment (not always successfully) to better suit their needs.

2.4 Conclusions

The natural environment of Northern Italy played a significant role in how the region developed during the Roman period. Its geography conditioned patterns of human settlement and activity, who, in turn, shaped the surrounding environment to better suit their needs. The wide alluvial plain and foothills hosted intensive agriculture, with settlers on the valley floor going to great lengths to maximise the land available for cultivation. This took the form of large-scale land reclamation in the areas closet to the watercourse, often linked to centuriation schemes, that served to expand the area available to arable and pastoral agriculture.

Many parts of the landscape were dominated by Northern Italy's extensive river network and its associated geomorphology, with the region hosting a complex system of rivers, lakes, and lagoons. Living adjacent to the water network was not without its hazards, with flooding, low flows, and channel movement presenting challenges. However, Roman interventions imply a level of mastery over the water network that would not be seen again until the early modern era. In terms of physical regime, the river network appears to have been stable in the Republican and Early Imperial period. However, from the third century onwards, a change in climate seems to have altered the characteristics of the river, with both the literary and archaeological evidence recording an increase in extreme hydrological events. This, combined with the degradation of flood prevention and drainage infrastructure, led to the loss of much of the land reclaimed during the Roman period.

Landscape and hydrology play an important role in the creation of transport networks, and the region's natural environment offered favourable conditions for their development. The density of the Po-Veneto plain's fluvial network enabled many parts of the region to be reached via water from the coast and vice versa, while the shallow gradient of the plain enabled easier and swifter overland travel than over more undulating terrain. This will be expanded upon in the next chapter, where the extensive archaeological evidence for boats and port infrastructure,

¹³² Tacitus, *Histories* 3.21.

¹³³ De Bon (1941), 29, 47–8.

roads, bridges, and viaducts across the Po-Veneto plain and into the mountains will be examined in an attempt to reconstruct Northern Italy's ancient transport network.

Chapter 3

Transport and Infrastructure

In the second century AD, the merchant L. Tettienus Vitalis, born in Aquileia and educated at Julia Emona, died in Turin.¹ On his grave monument, he complained about the hardships merchants endured, but also made reference to the two rivers that were essential to his business: the Po and the Sava.² These rivers provided east-west routes into Northern Italy and the Danubian *Limes*, and their inclusion on Vitalis' monument underpins the importance of fluvial networks in regional transport and trade. To successfully move cargoes of amphorae, finewares, stone, and other goods significant distances, an extensive and well-integrated transport network was essential. Northern Italy's waterways were utilised by cargo vessels for much of their length, although the seasonality of the water network and other unpredictable factors, such as low and high flows, might render the riverscape difficult to use at times. Northern Italy also possessed an extensive system of both major and minor roads that connected its principal population centres. The flat, level ground across much of the Po-Veneto plain allowed for swift and direct connections, taking goods and people to areas where the water network could not reach. They also provided an alternative to fluvial transport when poor conditions made rivers impassable, although it should be noted that periods of high flow could also have impacted terrestrial infrastructure (see Section 2.2.3). Building on the exploration of Northern Italy's landscape and hydrology from the previous chapter, the evidence for its ancient transport system explored here provides the next layer of canvas for the network analysis undertaken in Chapter 4.

¹ Gabucci and Menella 2003, 234.

² CIL V.7047; V.7127. *Have Vitalis. / L(ucius) Tettienus Vitalis, natus Aquie(i)a(e), / edocatus Iulia Emona, titulum pos(u)it / ante aeternam domum Iulia / Augusta Taurinorum. Dicit: / quaerere cessavi numquam, / nec perdere desi(i). Mors intervenit; / nunc ab utroque vaco. / Credite, mortales, astro nato / nihil est sperabile datum / terras nec minus et maria / impuri aqu(a)e Padi nec minus et Savi / ira(m). Quod optavi mihi tamen pervenit. / Perpetuam requiem pos(c)o.* See also Gabucci et al. (2000); Gabucci and Mennella (2003); Gregoratti (2015).

It can often be tempting to think of river and road transport as separate, even competing, systems, given that they functioned in vastly different ways and varied greatly in their haulage costs. However, this is misleading.³ Although river transport had the potential to be cheaper than road transport, it was not necessarily quicker, as moving upstream could take considerable time (see Section 4.2). Furthermore, roads were crucial for moving goods to areas not in the immediate proximity of a river, meaning that many inland journeys often needed to utilise both forms of transport to reach their desired destination. Both forms of transport involved the creation of major infrastructure, required to overcome obstacles along their routes. On the water network, ports were needed to provide the necessary equipment for the loading and unloading of cargo. Towpaths were essential for providing a continuous surface for the hauling of vessels, and human intervention was often needed to keep river channels open, involving dredging, channel cutting, or canalisation. On the road network, the construction of the road surface, even on level ground, was a substantial task. This could be compounded by the presence of obstacles such as steep slopes and rivers, requiring the creation of embankments and bridges. All required extensive organisation and maintenance. Together, they formed a combined transport network that provided a high level of access across Northern Italy.

This chapter examines the development and extent of Northern Italy's transport network during the Roman period. Evidence for the navigability of the region's rivers is synthesised and a catalogue of navigable rivers produced. Methods of movement and propulsion on the rivers and canals of Northern Italy are analysed, and, for the first time, its inland shipwreck evidence is presented alongside the evidence for port infrastructure on the region's waterscape. Turning to the road network, the challenges faced by terrestrial transport and the perception of its feasibility in modern scholarship are explored. The development of Northern Italy's roads is charted, and the specialised infrastructure created to overcome the obstacles present within the region, from the sodden ground of the delta to the steep Alpine passes, are analysed. Finally, the two networks are combined to highlight the breadth and diversity of transport routes and connections within Northern Italy. The locations of sites mentioned within this chapter can be viewed in Figure 3.1.

³ Adams (2012); Campbell (2012), 215-17; Laurence (2005), 138.

3.1 The Water Network

Literary and epigraphic evidence, supported by archaeological finds in the form of wrecks and port infrastructure, all attest to the use of Northern Italy's waterways for transport. The modern geomorphology of its rivers, however, cannot be taken as an accurate reflection of ancient navigability, since alterations to the fluvial landscape of the region mean that many rivers that were navigable in the Roman age, are no longer. For example, several rivers in Northern Italy, such as the Piave and the Scrivia, now exhibit braiding as their dominant geomorphology, making them difficult, if not impossible, to navigate.⁴ Nevertheless, both these rivers have produced evidence of port facilities dating from the Roman period.⁵ Firm evidence for ancient navigation exists on 26 rivers throughout Northern Italy, although there were probably many more (see Table 3.1 and Figure 3.2). These range from the Po itself to much smaller rivers such as the Enza and the Stella, suggesting a wide utilisation of the water network. Overall, there is little to suggest that the physical characteristics of the ancient Po water network prevented navigation in antiquity, yet this does not mean the entire network should be viewed as equally usable. To do so risks taking a simplistic view of river transport, where rivers can be traversed from source to sea, with no regard to their regime, hazards, or seasonality.⁶

Most navigation on the Po, its tributaries, and the rivers of the Venetian plain, probably took place on their middle and lower courses, the location of the majority of surviving evidence for fluvial transport. The wide, slower-moving channels of these sections of the river would have been usable by shallow-draft boats such as barges, although sand bars and other navigational hazards may have posed a risk.⁷ While the Po's high discharge and volume might be seen as an obstacle to navigation, it pales in comparison to other major rivers known to be navigable from the Roman period such as the Danube and the Rhine (see Table 3.2) and should not be seen as an impediment to waterborne traffic. There is little surviving evidence for navigation on the more variable and torrential upper courses located in the Alps and Apennines.⁸ These sections were unreachable by boat, due to the swifter current, lower water level, and greater presence of

⁴ Carton et al. (2009); Picco et al. (2013); Surian and Fontana (2017).

⁵ Cipriano and Sandrini (2001); Crosetto (2013b).

⁶ See Franconi ((2016), 27) for discussions on the complex array of factors needed to ensure successful fluvial navigation.

⁷ Overcoming such hazards often depended on the skill and local knowledge of a vessel's navigator.

⁸ Langdon ((2000), 80) highlights that even before reaching these unnavigable sections, there would likely have been a tail off in the amount of traffic the further one travelled upriver. Major fluvial ports are unlikely to be located at points of borderline navigability (something that might change seasonally or annually).

CHAPTER 3. TRANSPORT AND INFRASTRUCTURE

River	Ancient Name	Ports	Wrecks	Textual Reference	Epigraphic Reference
Po	<i>Padus/ Eridanus</i>	Bucci (2015)	Beltrame and Costa (2016); Parker (1992), (n. 864)	Ambrose, <i>Hexameron</i> 2.3.12; Appian, <i>Civil Wars</i> 2.3.17; Cassiodorus, <i>Variae</i> 2.31; Gaius Valgius Rufus, <i>Fragments</i> 167 (3 Bl., C.); 168 (4 Bl., C.); Livy, 21.57; Lucian, <i>The Amber, or the Swans</i> ; Polybius, 3.57; Pliny, <i>Natural History</i> 3.20; 16.70; Sidonius Apollinaris, <i>Epistles</i> 1.5.4 Pliny, <i>Natural History</i> 3.20; Sidonius Apollinaris, <i>Epistles</i> 1.5.4	CIL V.2315; CIL XI.0135
Adda	<i>Addua</i>				
Oglio	<i>Ollius</i>	Cavalieri Manasse (1990)		Pliny, <i>Natural History</i> 3.20	
Tanaro	<i>Tanarus</i>			Pliny, <i>Natural History</i> 3.20	CIL V.7679
Ticino	<i>Ticinus</i>			Pliny, <i>Natural History</i> 3.20; Sidonius Apollinaris, <i>Epistles</i> 1.5.4	AE 1977, 327
Mincio	<i>Mincius</i>			Catullus, 4; Pliny, <i>Natural History</i> 3.20	ILS 7265
Secchia	<i>Gabellus</i>			Pliny, <i>Natural History</i> 3.20	
Dora Baltea	<i>Duria Bautica</i>	Finocchi (1980); Brecciaroli Taborelli (2007)		Pliny, <i>Natural History</i> 3.20	
Panaro	<i>Scultenna</i>			Pliny, <i>Natural History</i> 3.20	
Sesia	<i>Sessites</i>	Spagnolo Garzoli et al. (2007)		Pliny, <i>Natural History</i> 3.20	
Stura di Demonte	<i>Stura</i>			Pliny, <i>Natural History</i> 3.20	
Enza	<i>Incia</i>			Pliny, <i>Natural History</i> 3.20	
Orco	<i>Orgus</i>			Pliny, <i>Natural History</i> 3.20	
Taro	<i>Tarus</i>			Pliny, <i>Natural History</i> 3.20	
Lambro	<i>Lambrus</i>	Caporusso (1990); Cera (1995)		Sidonius Apollinaris, <i>Epistles</i> 1.5.4	
Dora Riparia	<i>Duria</i>			Pliny, <i>Natural History</i> 3.20	
Trebbia	<i>Trebia</i>			Pliny, <i>Natural History</i> 3.20	
Scrivia	<i>Iria</i>	Crosetto (2013a); Gamberini et al. (2014)			
Reno	<i>Rhenus</i>			Pliny, <i>Natural History</i> 3.20	
Adige	<i>Athesis</i>		Tiboni (2009)	Sidonius Apollinaris, <i>Epistles</i> 1.5.4	CIL V.2722
Brenta	<i>Medoacus Maior</i>	Balista and Ruta Serafini (1993)	Beltrame (2001)	Pliny, <i>Natural History</i> 3.20	
Bacchiglione	<i>Medoacus Minor</i>		Previato and Zara (2014)	Strabo, 5.1.7	
Sile	<i>Silis</i>	Cipriano and Sandri (2001); Tirelli (1987)		Strabo, 5.1.7	
Stella	<i>Anaxum</i>		Castro and Capulli (2016)	Pliny, <i>Natural History</i> 3.22	
Lemene	<i>Romatinum</i>	Rousse (2013)		Strabo, 5.1.7-8 Pliny, <i>Natural History</i> 3.22	
Natisone	<i>Natiso</i>	Bertacchi (1980); (1990)	Bertacchi (1990); Beltrame and Gaddi (2013)	Pliny, <i>Natural History</i> 3.22	
Livenza/ Piave	<i>Liquentia</i>	Cipriano and Sandri (2001); Tirelli (1987)		Pliny, <i>Natural History</i> 3.22	
Tagliamento	<i>Tiliaventum Maior</i>			Pliny, <i>Natural History</i> 3.22	

Table 3.1: Rivers with evidence for navigation during the Roman period in Northern Italy.

River	Mean Discharge (m ³ /s)	Length (km)	Basin Size (km ²)
Danube	6500	2860	817,000
Nile	2830	6650	3,400,000
Rhine	2650	1230	185,000
Rhône	1700	810	95,000
Po	1540	650	74,000
Loire	850	1020	117,000
Garonne	630	640	55,000
Euphrates	555*	2780	444,000
Seine	500	770	78,650
Meuse	400	920	34,500
Guadalquivir	229	660	57,530
Tiber	260	400	17,370
Orontes	75	570	35,750
Thames	60	340	12,930
Maeander	35	550	25,000
Medjerda	32	480	23,700

Table 3.2: Mean discharge, length, and basin size of navigable rivers within the Roman Empire (After Franconi (2014), 35). *Euphrates data only available from Turkish border (80% total flow).

natural obstacles in the channel.⁹ Although the upper courses of the Po and its tributaries were inaccessible to conventional vessels, rafts of logs could probably be floated downstream from relatively high up the watercourse.¹⁰ This is a practice seen elsewhere in Roman Italy, where Pliny describes log rafts being transported downstream from the Tiber's upper course.¹¹ The above example highlights the bi-directional nature of fluvial navigation. Upstream and downstream travel utilised different methods, with upstream requiring much greater efforts and more favourable conditions (see Section 4.2). In this case, some parts of the water network may have been usable in one direction but not the other.

Seasonal variation in river flow could often be a governing factor for navigation. Too much or too little water in the river could cause problems for vessels, meaning some parts of the water network may only have been accessible at certain times of the year.¹² As highlighted in Chapter 2 (see Section 2.2.1), the Alpine and Apennine discharge regimes affected the river network at different times of year and in different ways, something that navigators would have needed to be aware of. Extreme hydrological events, themselves often a seasonal factor, would

⁹ Rieth (1998), 33-35.

¹⁰ Uggeri (1987), 333.

¹¹ Pliny, *Natural History* 3.53; Rieth (1998), 54-55.

¹² The best-known example of seasonal limitations is the Nile, where navigation was often dependent on water levels generated by the annual flood (Adams (2018), 175-77; Cooper (2011), 195-97).

also have prevented the use of the region's waterways. Although Pliny claimed that flooding on the Po caused 'more damage to the fields than to vessels' on the river, watercraft were not immune to the dangers it represented.¹³ Indeed, several Roman wrecks recovered in the region, including the Corte Cavanella I, Santa Maria in Padovetere, and Stella I wrecks, seem to have been lost during flood events.¹⁴ Flooding would have obscured the path of the channel, leaving a vessel vulnerable to hidden underwater hazards or getting stranded as waters receded. The fast current would also have made controlling the path of a vessel difficult, if not impossible, alongside carrying debris that could strike and damage the craft. Even moored vessels might not have been safe. A vessel secured too tightly to the bank will tilt in a fast current, allowing water to pour in over a low gunwale or any open ports. Alternatively, the stronger current of the flood wave may put stress on already overstressed moorings, causing them to break and leave a vessel floating free in the flood. Periods of low flow could be equally hazardous as flooding for navigation, increasing the risk of a vessel impacting the riverbed or becoming beached.

3.1.1 The Development of the Fluvial Transport Network

Some of the earliest references to Roman navigation on the waterways of Northern Italy come from accounts of the Second Punic War.¹⁵ Polybius describes the Po as being 'navigable for about two thousand *stades* from the mouth called Olana', while Livy records several instances of the Po being used to transport supplies to embattled Roman units between Piacenza and Pavia, demonstrating that even during this early period, the potential of the river as a transport artery was exploited.¹⁶ By the first century AD, the waterways of the Po valley were organised around two axes of travel. The first was the system of para-littoral canals that facilitated north-south travel between the major seaports of the region, Ravenna, Altinum, and Aquileia (see below). The second was the Po river network itself, which provided east-west connections into the interior of Northern Italy. Together these networks enabled merchants such as L. Tettienus Vitalis to distribute extra-regional cargoes from the coast to the interior along the waterways, and vice versa for cargoes originating from inland. This period also saw significant investment in port infrastructure on the banks of the Po and its tributaries, including the construction of new port facilities at Ivrea, Milan, Oderzo, Tortona, and Vercelli

¹³ Pliny, *Natural History* 3.118.

¹⁴ Beltrame et al. (2021), 44-46; Castro and Capulli (2016), 39; Sanesi et al. (1985), 15-16.

¹⁵ The waterways of Northern Italy were already being utilised for transport in the pre-Roman period (Medas (2018), 146; Ortalli (1995), 64; Roncaglia (2018), 9).

¹⁶ Livy, 21.25; 21.57; Polybius, 2.16.

Location	Feature	Profession	Reference
Adria	The Po	<i>Collegia Nautarum</i>	CIL V.2315
Arco	Lake Garda	<i>Collegia Nautarum</i>	AE 1977, 298
Augusta Bagiennorum	The Tarano	<i>Nauta</i>	CIL V.7679
Brescia	Lake Garda/The Oglio	<i>Collegia Nautarum</i>	AE 1977,298
Cantù	Lake Como	<i>Nauta</i>	AE 2003, 728
Como	Lake Como	<i>Collegia Nautarum</i>	CIL V.5295
Este	The Adige	<i>Nauta</i>	CIL V.2722
Mantua	The Mincio	<i>Collegia Nautarum</i>	ILS 7265
Milan	Lake Como	<i>Collegia Nautarum</i>	CIL V.5911 = AE 2014, 440
Milan	The Lambro?	<i>Collegia Nautarum</i>	AE 2014, 520
Pavia	The Ticino	<i>Collegia Nautarum</i>	AE 1977, 327
Peschiera del Garda	Lake Garda	<i>Collegia Nautarum</i>	CIL V.4016 = ILS 8373
Peschiera del Garda	Lake Garda	<i>Collegia Nautarum</i>	CIL V.4017 = ILS 8372
Peschiera del Garda	Lake Garda	<i>Collegia Naviculariorum</i>	CIL V.4015 = ILS 6711
Ravenna	The Po	<i>Nauta</i>	CIL XI.0135
Riva del Garda	Lake Garda	<i>Collegia Nautarum</i>	CIL V.4990

Table 3.3: Inscriptions relating to *nautae* and *collegia nautarum* in Northern Italy.

(see below). Literary accounts dating to this period frequently mention sailors, rowers, and boatmen, suggesting there was a strong tradition of working on the waterways of the region. This is supported by the existence of several known *collegia nautarum* that operated on Po, its tributaries, and the lakes of the region (see Table 3.3).¹⁷ *Collegia* are known to have operated out of Adria, Brescia, Como, Milan, Mantua, and Pavia, and their proliferation during this time points to increasing organisation and commerce on the water network.

The first and second centuries AD would form the high point of investment on the water network. Between the third and fifth centuries, much of the terrestrial infrastructure on the water network would fall into disrepair. Dock infrastructure at Corte Cavanella, Milan and Ivrea fell out of use at this time, and the artificial channels and drainage schemes undertaken during the Republic and Early

¹⁷ Broekaert (2013). It has been highlighted in the past that for a navigable river system, the water network of Northern Italy has returned remarkably few inscriptions referencing *nautae* in comparison to other regions such as Gaul and Germany (Harris (2011b), 192). While this may be true for inscriptions that only mention *nautae* (Northern Italy contains only three, in comparison to twenty-six from Gallia Lugudunensis), of the thirty-three known inscriptions specifically referring to *collegia nautarum* within the Roman Empire, eleven come from Northern Italy – a third. Many of the Gallic inscriptions relate to the Rhône and the Saône in particular (see Campbell (2012), 267-70 for more information on *nautae* in Gaul). The number of inscriptions is based on the listings found in the Epigraphik-Datenbank. http://db.edcs.eu/epigr/epi_ergebnis.php (Accessed 10/03/20).

Imperial period began to fail or silt up due to a lack of maintenance (see Section 2.3).¹⁸ The para-littoral canals would also be abandoned by the end of the fourth century (see below). In some isolated cases, this decline was matched by new investment elsewhere. The re-excavation of the harbour channel at Tortona during the mid-third century prolonged its use (though with a reduced capacity) into the sixth century, and a new port was constructed at Brescia during the fifth century.¹⁹ While evidence for the degradation of physical infrastructure is fairly uniform across the region, there are extensive references to navigation on the Po in the fourth-sixth centuries.²⁰ The travels of Sidonius Apollinaris from Pavia on the region's waterways have already been mentioned above, and Cassiodorus, writing in the sixth century, ordered Pavia to provide the Herulii with boats to sail to Ravenna, suggesting the continuity of this route.²¹ Elsewhere, Cassiodorus praises travel on the waterways of the region, specifically the rivers of Veneto, as the keels of ships 'fear no rough blasts (from waves); they touch the earth with the greatest pleasure, and cannot perish however frequently they may come in contact with it'.²² There are also mentions of the need to remove large quantities of fishing nets from the Mincio and the Oglio that were impeding the passage of boats, suggesting a concern in keeping waterways open.²³ Although the previous chapter suggested a changing climate may have created problems for riparian communities in Northern Italy, it does not seem to have prevented their use for transport during Late Antiquity and the Early Medieval period.

3.1.2 The Para-Littoral Canals

One of the most ambitious engineering projects the Romans undertook in Northern Italy was the construction of a system of para-littoral canals along the Adriatic coast. These canals formed an important part of the water network, from both a transport and hydrological standpoint. Canals could join formerly separate river basins together, redirect the flow of water away from areas where it had previously travelled, or connect sections of a river to the sea. The system was composed of three canals, the *Fossa Augusta*, the *Fossa Claudia*, and the *Fossa Flavia*, which connected the ports of Ravenna and Altinum over a distance of

¹⁸ Cera (1995), 186-191; Sanesi et al. (1985), 22-23.

¹⁹ Cera (1995); Crosetto (2013b), 108-110.

²⁰ For more on the water network of Northern Italy during the Medieval and Early Modern periods see Covini (2010); Galvani and Pellegrini (2010); Greci (2016); and Laven (1989).

²¹ Cassiodorus, *Variae* 4.45.

²² Cassiodorus, *Variae* 12.24.

²³ Cassiodorus, *Variae* 5.17. Human additions to the fluvial landscape could often impede navigation as much as natural processes (Jones (2000), 60-69).

120 Roman miles (see Figure 3.3).²⁴ The three waterways are recorded in the Peutinger Table (see Figure 3.4), and the *Antonine Itinerary* alludes to them by detailing the quickest route from Ravenna to Altinum was to sail through ‘the Seven Seas’.²⁵ It is also possible that the canal system had been extended as far as Aquileia by the reign of Diocletian through the remainder of the lagoon system.²⁶ It would be a mistake to envisage these canals in the traditional sense of a continuous excavated channel. The para-littoral *fossae* connected multiple branches of the Po, at times by diverting them, and utilised the coastal lagoons for large sections of their course.²⁷ The creation of the canal system allowed vessels to travel between ports along the Northern Adriatic coast without being exposed to the perils of the sea, and would have enabled maritime ships to bypass the dangerous mouths of the delta to access the Po, which, according to Strabo, ‘could only be overcome with experience’.²⁸

The *Fossa Augusta* was constructed during the reign of Augustus and connected Ravenna to the southernmost channel of the Po.²⁹ It was probably created in tandem with the founding of the naval base at Ravenna and would have allowed products travelling on the inland waterways to more easily reach the port.³⁰ Excavation has returned evidence of the *Fossa Augusta* in several areas. Extensive coring has revealed its path to the immediate north of Ravenna, and within Ravenna itself, several sections have been excavated (see Figure 3.5).³¹ The excavated sections reveal the canal had a width of 50m, and its bank was reinforced with wooden stakes in sections (see Figure 3.6). At several points along the path of the canal, there is evidence for dock facilities constructed in concrete and masonry, in some cases with adjacent warehouses and workshops.³² A road also ran parallel to the canal and was paved in the areas closest to Ravenna. This may have acted as a towpath for vessels using the channel. The route of the *Fossa Augusta* can be mapped with a good degree of accuracy until it reaches the la-

²⁴ Pliny, *Natural History* 3.119; Uggeri (1978). The first to excavate navigable artificial channels within the Po-Veneto plain were supposedly the Etruscans, who excavated a canal to maintain sea access to the port of Atria (Pliny, *Natural History* 3.120).

²⁵ *Itinerarium Antonini Augusti*, 126.

²⁶ Herodian, 8.7.1; Uggeri (1987), 343; (1997), 60.

²⁷ Using canals to connect rivers is seen elsewhere in the Roman world. The *Fossa Corbulonis* in the Netherlands was constructed in AD 50 to connect the mouths of the Meuse and the Rhine, while the *Fossae Drusianae*, the exact routes of which are unknown, possibly connected the Rhine with Lake Flevo (Franconi (2014), 41-44).

²⁸ Strabo, 5.1.5. Parallels are drawn to the mouth of the Rhône, another river whose delta was said to provide difficult passage for ships. Here too, a canal was built, the *Fossa Mariana*, in order to bypass the mouth of the river (Strabo, 4.1.6).

²⁹ Pliny, *Natural History* 119.

³⁰ Uggeri (2016), 88.

³¹ Cirelli (2013), 117-19; Grazia Maioli (1990), 380-82; (2018), 333-34; Manzelli (2000), 161-62.

³² Roncuzzi (1992), 725; Roncuzzi and Veggi (1967); (1968).

goon of the Valli di Comacchio about 15 km north of Ravenna, where its path is lost.³³

There is less evidence for the *Fossae Claudia* and *Flavia*. *The Fossa Claudia* was probably constructed during the reign of Claudius, and while its path is uncertain, the modern town of Chioggia likely takes its name from the canal and represents the point it entered the Venetian lagoon.³⁴ *The Fossa Flavia* is thought to have been begun during the reign of Nero and completed by the Flavian dynasty.³⁵ The *fossa* seems to have revived an older Etruscan canal that was constructed by diverting a branch of the Po across the marshes south of Atria, connecting the Caprisian branch to the Volanian branch.³⁶ Though no sections of the *Fossae Claudia* and *Flavia* have been excavated, there is circumstantial archaeological evidence for their presence. Foundations of structures interpreted as towers or lighthouses have been discovered along the proposed route of the canals, which could have acted as markers for vessels seeking to enter the canals from the lagoon system (see Figure 3.7).³⁷ Several stone mooring rings have also been recovered from the Valli di Comacchio, which may indicate docks from either a canal or a channel of the Po.³⁸ Furthermore, many of the inland wrecks recovered from the coastal regions are located along the proposed path of the canal, most notably the Corte Cavanella I and II wrecks (see below).

The canals themselves seem to have had extraordinary longevity, staying in service for approximately 300 years. In the third century, Herodian described the Emperor Maximus leaving Ravenna and travelling to Aquileia via ‘the lagoons into which the River Eridanus and the surrounding swamps empty’, suggesting that the para-littoral canals had been extended through the northern lagoon system.³⁹ An extension of the canals is further supported by the Aphrodisian copy of the Price Edict, which gives a cost of 7500 *denarii* to ship 1000 *kastrenses modii* from Ravenna to Aquileia during the fourth century AD.⁴⁰ However, during this later period there is already evidence of siltation within the *Fossa Augusta* and the surrounding lagoon system, which would have reduced the effectiveness of

³³ Manzelli (2000), 162.

³⁴ Pliny, *Natural History* 121; D’Agostino and Medas (2010), 288; Uggeri (1987), 341.

³⁵ This is due to the location of the town of Neronia along the path of the canal, just as there is the town of Augusta along the path of the *Fossa Augusta*.

³⁶ Pliny, *Natural History* 3.120.

³⁷ D’Agostino and Medas (2010), 289-90; Madricardo et al. (2021); Uggeri (2006), 145-48. On clear days, the tower would have acted as a prominent marker, while during darkness the light would have been able to guide vessels towards the canal entrance.

³⁸ Uggeri (1990), 185.

³⁹ Herodian, 8.7.1.

⁴⁰ *Edict of Maximum Prices*, XXXVA.33; Laurence (1999), 118; Uggeri (1987), 343; (1997), 60. The journey is assumed to have been via canal due to the total cost being substantially higher than the cost of the maritime route between the two ports when measured using the Price Edict.

the channel.⁴¹ This may suggest that the dredging required to keep it operational had ceased or was no longer being carried out as frequently. Its use persisted, but by the end of the fourth century, the canal seems to have been abandoned.⁴² The fate of the other two canals is, unfortunately, less certain, due to a lack of records and firm archaeological evidence.

The construction of para-littoral canals represented a significant Roman undertaking during the first century AD to alter the water network of Northern Italy to their advantage and enhance the opportunities it offered. The creation and maintenance of these canals was a substantial task, often involving either the redirection of a watercourse or the creation of an entirely new one. During their lifetimes, the para-littoral canals represented a key piece of hydrological infrastructure within the Po-Veneto plain, one that was used to extend the water network, alongside opening it up to fluvio-maritime transport along the Adriatic coast.

3.1.3 Moving on the Waterways

While Northern Italy's waterways were extensive, travelling upon them involved a complex array of skills and methods. Fluvial transport is bi-directional, with upstream and downstream travel facilitated in different ways. When travelling downstream, a vessel could simply coast along with the current, needing only simple manoeuvring to maintain direction and avoid obstacles. Of course, additional forms of propulsion, such as sails or oars, could be added to speed up a journey or enhance control over a vessel, something especially important for heavier cargoes. Upstream travel was a different story entirely. Rather than moving with the current, a vessel heading upriver had to actively fight against it, and some form of propulsion was required to overcome the force of the river. Occupying a middle ground between the two was canal transport. Canals mainly consist of still or very slow-moving water, which meant that, while there was no current to battle against, there was also no source of propulsion for travel. This meant a vessel required a driving force to move in either direction. In the ancient world there were three main forms of propulsion used on the waterways: sails, oars, or towing, with evidence for the use of all three coming from Northern Italy.

There are several first-hand accounts of travel on the Po surviving from the Roman era. The poet Gaius Valgius Rufus, writing in the Augustan period, described entering the river from the Adriatic, 'where the mouth of the canal links peaceful Padusa, [the ship] sails the great stream of the Alpine Po'.⁴³ At

⁴¹ Manzelli (2000), 236.

⁴² Manzelli (2000), 238.

⁴³ Gaius Valgius Rufus, *Fragments* 167 (3 Bl., C.).

some point during the journey the method of propulsion changed, as he described ‘my ship, following a long tow-rope, set me down rejoicing in a delightful place of hospitality’.⁴⁴ A second account comes from the satirist Lucian, writing in the second century AD, who set his short work *The Amber, or the Swans on the Po*. Told from Lucian’s perspective, the author recounts a journey he made when he needed to ‘go up the Eridanus’.⁴⁵ During the journey, he asks the boatmen if they have seen any precious amber in the river, to which they reply, ‘If we had anything of that sort, do you suppose that for two *obols* we would row or tow our boats upstream’.⁴⁶ The final account comes from the fifth century AD, when Sidonus Apollinaris recounts in detail a journey he took down river from Pavia to Ravenna.⁴⁷ Whilst on the Po, Apollinaris used the opportunity to explore several of the river’s tributaries and in each case ‘cruised a little way upstream from the point of confluence so as to view each actually in the midst of its own waters,’ before changing rowers at Brixellum and proceeding the rest of the way to Ravenna.⁴⁸ The above accounts reflect the importance of the Po river network in providing transport, not just for cargo, but also for people. Ferry services travelled upstream and downstream, and transport provision provided a living for people that lived along the banks. Strabo documents the existence of a boat service between Piacenza and Ravenna that took two days and nights, while in the fifth and sixth centuries, Cassiodorus documents the deployment of naval fast rowers (*dromonarii*) on the river to aid the *cursus publicus*.⁴⁹

The textual evidence suggests a variety of methods were used to move along the waterways of Northern Italy. Rowing proved a popular and versatile form of propulsion along the river, with depictions of ships being moved under oar power featuring prominently on several reliefs from elsewhere in the Western Empire (see Figure 3.8, for example).⁵⁰ In addition to rowing as a method of propulsion, both Valgius Rufus and Lucian mention the use of towing, famously represented by a second century AD relief from Avignon (see Figure 3.9). Towing a vessel requires significant time, energy, and infrastructure. The presence of a tow path is near-essential, as this provides a solid and level surface for the towers, seemingly human instead of animal in this case. Yet many areas of land directly adjacent to the Po or its tributaries were marshy, despite the intervention of drainage works.

⁴⁴ Gaius Valgius Rufus, *Fragments* 168 (4 Bl., C.).

⁴⁵ Lucian, *The Amber, or the Swans* 1.

⁴⁶ Lucian, *The Amber, or the Swans* 3.

⁴⁷ Sidonius Apollinaris, *Epistles* 1.5.

⁴⁸ Sidonius Apollinaris, *Epistles* 1.5.5.

⁴⁹ Cassiodorus, *Variae* 2.31; Strabo, 5.1.11. Seneca (*De Beneficiis* 6.19) also records using ferry services to cross the Po.

⁵⁰ Campbell (2012), 211. Rieth ((1998), 103) makes the case that even large or heavily laden vessels could be rowed under the right conditions.

Indeed, Sidonius Apollinaris observed that the river's 'banks and knolls were everywhere clad with groves of oak and maple' for all this growth, 'nourished on the moisture of the spongy soil, had sprouted confusedly along the riverbanks'.⁵¹ This raises the question of whether the construction of a towpath would have been feasible along the entirety of the river. Medas has hypothesised that the embankments and dykes constructed along the Po could have served as a tow path in some areas, but again, they were unlikely to have been constructed along the entirety of the river network (see Section 2.3.2).⁵² In *The Amber, or the Swans*, Lucian's conversation with the boatmen seems to imply that they were involved in both rowing and towing vessels on the river and in areas where there was no towpath, it is possible the towers could have switched to rowing as an alternative form of propulsion.⁵³

Although rowing and towing seem to have been the most common methods of moving on the waterways, the use of sails as a method of propulsion is confirmed by Pliny, who describes them as being woven out of strong rushes in some cases.⁵⁴ The Po-Veneto plain, being surrounded by mountains on three sides, is largely sheltered from wind. The Alps and Apennines block the majority of northern, westerly, and southerly winds, and as a result, the prevailing wind in the region is an easterly one, coming in over the Adriatic. Consequently, the use of sails, backed by the favourable prevailing easterly wind, could have helped counteract the force of the current for boats sailing upstream on the Po.⁵⁵ It is worth highlighting, however, that there are practical limitations to using wind power as a form of propulsion. Sails are best suited to large, open expanses of water where there is space to tack (if the wind was not behind the vessel), rather than the narrow confines of the river channel. The curve of a meander might result in the sails being unable to take full advantage of the breeze.⁵⁶ Furthermore, the intermittent nature of the wind makes it a somewhat unreliable form of propulsion, and sails were best combined with other methods. This is reflected in Valgius Rufus' account of his journey on the Po, where his ship begins by sailing up through

⁵¹ Sidonius Apollinaris, *Epistles* 1.5.4. It is possible that this surge in growth and marshland relates to the degradation of drainage infrastructure in Late Antiquity (see Section 2.3.1), but other, earlier authors also relate to their presence during the Late Republic and Early Imperial periods (see Section 2.2).

⁵² Medas (2018), 148-49.

⁵³ Lucian, *The Amber, or the Swans* 3.

⁵⁴ Pliny, *Natural Histories* 16.70.

⁵⁵ Rieth (1998), 100-101. He also highlights the east-west orientation of river basins in Western France as a factor for the widespread use of sail-powered craft on them. This orientation is favourable to catch the prevailing western wind of the Atlantic coast as a method of upstream propulsion. See also Cooper ((2011), 197-98) for an assessment on the impact of wind on Nile navigation.

⁵⁶ Rieth (1998), 101.

the mouth of the river, before at an unspecified point alternating to towing as its main form of propulsion.⁵⁷ In sum, the surviving literary evidence suggests that watercraft in Northern Italy were propelled by a variety of means. The milieu of river, lake, and canal environments afforded multiple methods of river travel depending on the situation at hand, something that is reflected in the variety of vessels recovered from the region.

3.1.4 Vessels and Cargoes

While the majority of information concerning ancient activity on the water network comes from surviving textual sources, Northern Italy's wreck evidence has long been overlooked. Indeed, over the past thirty years the number of wreck discoveries have steadily increased, with the publication of eighteen wrecks that can be dated to the Roman period (see Table 3.4). The wrecks range chronologically from the first century BC to the fifth century AD. In size, they vary from small sections of surviving planking (in the case of the wrecks from Aquileia and the Venice Lido) through to the 20 m long hull of the Comacchio wreck which had a displacement of 130 t.⁵⁸ They are principally located in the east of the study area, in the coastal region between Ravenna and the Venetian lagoon system, although some have been recovered from further inland (see Figure 3.10).

It warrants mentioning that, despite the extensive shipwreck evidence in the eastern coastal regions, only a single plank-built vessel from the Roman era (the Santa Maria in Padovetere wreck) has been recovered from the Po and its major tributaries.⁵⁹ Given the quantity of surviving Roman organic material in the region, poor preservation conditions do not seem an adequate explanation for the lack of discoveries.⁶⁰ Instead, there could be several other possible explanations. First, the Po, alongside many other rivers in the region, has moved extensively since the Roman period, at times up to tens of kilometres from its original bed.⁶¹ This means that any potential wrecks are buried under a deep layer of later alluviation in the river's paleochannels. Second, shipwrecks in rivers, and most importantly their cargo, are far easier to salvage than those that occur at sea. Whilst a wreck on the seabed would have been permanently out of reach (in most cases) of potential recovery, salvagers would only need to wait for a period

⁵⁷ Gaius Valgius Rufus, *Fragments* 167 (3 Bl., C.); 168 (4 Bl., C.).

⁵⁸ The fragmentary nature of many of the wrecks makes it hard to accurately assess their size.

⁵⁹ The Santa Maria in Padovetere wreck was discovered in a Roman era paleochannel of the Po (the *Padus Vetus* – Padovetere) close to Comacchio. By the time the loss of the vessel occurred, the channel (previously some 500 m in width) had become residual as the Po's path shifted north (Beltrame et al. (2021), 30-31).

⁶⁰ For example, the survival of wooden port infrastructure on the Po and its tributaries discussed below.

⁶¹ Bridge (2003), 310-11; Corrà and Mozzi (2017), 490; Uggeri (1990), 179.

Wreck	Date	Cargo	Publication
Aquileia I	First Century AD	Unknown	Bertacchi (1990)
Aquileia II	Second-Third Century AD	Unknown	Beltrame and Gaddi (2013)
Bacchiglione	First Century BC	Shaped Blocks of Euganean Trachyte	Previato and Zara (2014)
Cavanella d'Adige	Second-First Century BC	Unknown	Tiboni (2009)
Comacchio	First Century BC	Iberian lead pigs, Adriatic ceramics and amphorae, plus other.	Berti (1990)
Como	'Roman'	Musso Marble	Montalcini De Angelis D'Ossat (1993)
Corte Cavanella I	First-Second Century AD	n/a	Sanesi et al. (1985)
Corte Cavanella II	First-Second Century AD	n/a	Sanesi et al. (1986)
Largo Europa	Second Century AD	n/a	Balista and Ruta Serafini (1993); Beltrame (2001)
Lido I	First Century AD	Unknown	Beltrame (1996)
Lido II	First-Second Century AD	Unknown	Beltrame (2002a)
Lido III	First-Second Century AD	Unknown	Willis and Capulli (2018)
Monfalcone	First Century AD	Unknown	Bertacchi (1976)
Parco Teodorico	Fifth Century AD	Unknown	Medas (2003b)
Pontelagoscuro	'Late Roman-Early Medieval'	Unknown	Parker (1992)
San Basilio di Ariano Polesine	'Roman'	Domegliara Limestone	Dallemulle (1977)
Santa Maria in Padovetere	Fourth-Fifth Century AD	Unknown	Beltrame and Costa (2016); Beltrame et al. (2021)
Stella	First Century AD	Brick and Tile	Castro and Capulli (2016)

Table 3.4: Wrecks dating to the Roman period discovered in inland Northern Italy.

of calm or low flow before accessing a river wreck. Fluvial wrecks could also have impeded the usability of the channel for other vessels, giving additional impetus for their salvage and removal.⁶² Third, few people live near the modern Po channel. The area in the river's vicinity is predominantly rural, with few roads running parallel to the river. This means that any potential wrecks exposed by the river, often during flood events, are unlikely to be spotted immediately. With the exception of the Santa Maria in Padovetere wreck, the only Roman era vessels so far recovered from the Po itself have been monoxyls (log boats). These are often disturbed during flood events or channel changes, and due to their small size and homogenous construction, once exposed are often carried downstream before being found, often in proximity to bridges or built-up areas.⁶³ Larger wrecks, inevitably more fragile, do not behave in the same way during flood events and are more likely to be destroyed or broken up by the force of the river. While the above circumstances contribute to the low discovery rate for wrecks from within Northern Italy, those recovered from the coast can still offer important insights into the vessels travelling on the water network of the Po-Veneto plain.⁶⁴

⁶² Wrecks were often recycled, as shown by the recovery of the Largo Europa in Padua and the Corte Cavanella II. Both ships were broken up and reused in later structures, the former as an embankment and the latter as a jetty (Balista and Ruta Serafini (1993); Beltrame (2001); Sanesi et al. (1986)).

⁶³ Allini et al. (2014), 117-18; Ravasi and Barboglio (2008), 39-48.

⁶⁴ It is also worth considering a significant portion of the traffic on Northern Italy's water net-

Concerning the findspots of the wrecks, the Comacchio, Lido I-III, Monfalcone, and Parco Theodorico wrecks were recovered from areas corresponding to the ancient coastline, which has long since prograded eastwards. The rest were recovered from contexts which were inland during the Roman period, within active rivers or paleochannels. The contexts of other wrecks, such as the Corte Cavanella I and II, the Cavanella d'Adige, the San Basilio di Ariano Polesine, and Santa Maria in Padovatore, match the proposed locations of the para-littoral canals that linked Ravenna and Altinum (see above).⁶⁵ This is especially true for the Corte Cavanella wrecks, which were recovered from a settlement, possibly a villa, founded in the early first century AD in the delta region near modern Comacchio.⁶⁶ The first vessel was discovered in the remains of a boathouse adjacent to a small canal. The boathouse had been covered by a tile roof which had later collapsed in a flood event, sealing the wreck beneath the rubble (see Figure 3.11).⁶⁷ The second vessel was found a short distance away, where the flat bottom of its hull had been recycled as a jetty (see Figure 3.12). Although it is possible that the Corte Cavanella I could have been used as a small cargo barge (7.45 x 2.11 m in its surviving section), the Corte Cavanella II is too small to have fulfilled this function and was probably a personal watercraft.⁶⁸ The Bacchiglione and Stella I wrecks were found within the rivers from which they take their names, and the Como wreck was recovered from the lake of the same name.⁶⁹

The wrecks of Northern Italy, with the exception of the Monfalcone and the Parco Teodorico wrecks, were constructed using a method known as the sewn plank technique. Planks are joined together using cording, which is looped through holes drilled through the wood.⁷⁰ These holes are then pegged and sealed with calking (see Figure 3.13). While this practice is seen elsewhere in the Mediterranean during the Roman period, there was a widespread tradition of sewn plank naval construction in the Northern Adriatic.⁷¹ The level of structural

work may be invisible in the archaeological record, regardless of survival or not. As highlighted above, rafts might be used to transport goods down a river, with the raft itself comprising part of the cargo (Diosono (2009), 266; Meiggs (1982), 336). Vitruvius, *de Architectura* 2.9.16 records that larch was transported down the Po, and the simplest and most economical method of achieving this would have been to float it downriver, rather than transport it within a vessel.

⁶⁵ Beltrame and Costa (2016), 263; Uggeri (1978); (1987).

⁶⁶ Sanesi et al. (1985); (1986). The settlement is often equated with the location of a canal side *mansio* on the Peutinger Table, however there is little other evidence for this interpretation.

⁶⁷ Sanesi et al. (1985), 15-16.

⁶⁸ Sanesi et al. (1986), 27.

⁶⁹ Montalcini De Angelis D'Ossat (1993); Previato and Zara (2014).

⁷⁰ See Beltrame (2001); (2002a); (2002b); Beltrame and Gaddi (2013).

⁷¹ Beltrame and Gaddi (2013), 303; Beltrame et al. (2021), 29; Willis and Capulli (2018), 352-54. There have been several finds of sewn plank vessels off the coast of Southern France such as the Cavalière wreck and the Cap Bear C wreck (Charlin et al. (1978)).

elasticity the method afforded may have been advantageous in a shallow water environment where landings and impacts on the hull would have been frequent.⁷² The majority of Adriatic examples had flat bottomed hulls, a design for which sewn plank construction was especially suited.⁷³ These long, shallow draught vessels were perfect for moving on inland waterways and sheltered lagoons, where the absence of waves and currents on the inland waterscape removed the need for keel.

Although many of the wrecks recovered from the region were flat-bottomed, several belong to a tradition of ship building described as fluvio-maritime. The Comacchio wreck had a shallow, rounded hull with a rudimentary keel, making it suited to both fluvial and maritime operations, a design also seen in the Monfalcone and the Parco Teodorico wrecks (see Figures 3.14, 3.15, and 3.16).⁷⁴ Elsewhere in the Empire, the Blackfriars I wreck recovered from the Thames was designed with the same functionality in mind.⁷⁵ Given the extensive network of waterways in the Po valley, it is unsurprising that maritime vessels were designed to take advantage of the inland routes and the access they offered to the interior.⁷⁶ The design would also have allowed use of the para-littoral canals, avoiding a potentially dangerous voyage along the coast. Indeed, it is striking that all the wrecks recovered from the ancient coastline were discovered near harbour access points. The Comacchio wreck was recovered in proximity to the former mouth of the Po, and the Parco Teodorico wreck was located near the entrance to the harbour of Ravenna. The Lido I-III wrecks were recovered near the access points to the Venice lagoon and, by extension, the port of Altinum and the para-littoral canals.

Among the wrecks recovered from further inland or riverine contexts, the Stella I and Santa Maria in Padovetere wrecks have both been identified as flat-bottomed cargo barges.⁷⁷ They were both constructed without a keel and have a long, narrow box shape, similar to other barges found in the Western Empire such as the Zwammerdam 2, 4, and 6, the Lyon Parc Saint-Georges 4, or the Arles-Rhône 3 (see Figures 3.17 and 3.18).⁷⁸ Even fully loaded, barges could have a

⁷² Medas (2018), 152.

⁷³ Beltrame (2002a), 358.

⁷⁴ Willis and Capulli (2018).

⁷⁵ Marsden (1967). See again, the account of Gaius Valgius Rufus whose ship entered the Po directly from the Adriatic.

⁷⁶ Elsewhere in Italy, the Tiber was also said to be navigable by ocean-going vessels up to Oriculum (Diosono (2012), 200).

⁷⁷ Other fragmentary vessels, such as the Cavanella d'Adige, Aquileia I and II may also have functioned as barges (Beltrame and Gaddi (2013), 301; Bertacchi (1990), 220-26).

⁷⁸ Bockius (2004); De Weerd (1978); Rieth (2014); Rieth and Guyon (2011). The Arles-Rhône 3 had a capacity of between 25 and 29 t, with the Bacchiglione (accounting for missing cargo) and the San Basilio di Ariano Polesine wreck sharing a similar capacity (Dallemulle (1977), 123-

very low displacement, at times as little as 10 cm.⁷⁹ In Northern Italy the Stella I wreck was carrying a local cargo towards Aquileia when it sank (see Figure 3.19).⁸⁰ The Stella is a small river, a fraction of the size of the Po, the Adige, or any of the other major waterways in the region. The fact that a boat the size of the Stella I (2 x 4.9 m in its surviving bow section) was able to use the river attests to the versatility of these vessels in operating in restrictive conditions, and the accessibility of even the smallest waterways to cargo bearing vessels.⁸¹ In contrast, the fifth century AD Santa Maria in Padovetere wreck (see Figure 3.20) provides a more complete example of a cargo barge from the region, with its hull surviving to a length of 17m.⁸² Its cargo is unknown, but the wreck was located in the remains of a fossilised river channel that connected Ferrara (and the Po) to Ravenna. The proposed path of the *Fossa Augusta* is also less than a kilometre away from the wreck site, although the canal had fallen out of use by the fifth century AD (see Section 3.1.2).

The final wreck type recovered from the region are monoxyls, log boats carved from a single tree trunk that could reach up to 18 m in length.⁸³ They were probably used for fishing, or other small-scale economic activities and may have also allowed the transport of small groups of people over short distances. While the process of making a basic monoxyl was reasonably simple, some of the recovered monoxyls show considerable sophistication, and could carry sails or be combined to form catamarans.⁸⁴ They have been recovered from rivers and lakes across Northern Italy, and demonstrate that even people without access to larger, more sophisticated vessels were utilising the water network.

As to what goods may have been transported on the waterways, few cargoes have been recovered from inland wrecks within Northern Italy.⁸⁵ In some cases,

24; Previato and Zara (2014), 72; Rieth (2014), 285.). Outside of the fluvio-maritime vessels, there is so far little evidence to suggest there was anything larger travelling on the waterways of Northern Italy.

⁷⁹ Bockius (2004), 109.

⁸⁰ The makers stamps present on the roof tiles recovered from the wreck have a distribution across the Upper Adriatic region (Castro and Capulli (2016), 31).

⁸¹ Castro and Capulli (2016), 32.

⁸² Beltrame and Costa (2016); Beltrame et al. (2021).

⁸³ Medas (2003a), 162; Uggeri (1990), 188-89.

⁸⁴ Ravasi and Barbaglio (2008), 39-48.

⁸⁵ Most ancient literature concerned with transport on the Po water network focuses on passengers being transferred up and downriver in the Roman period. Accounts mentioning material cargoes are less common, but they do exist. Livy (21.57) mentions that during the winter of 218/217 BC, Hannibal's forces were harassing Roman troops in their winter quarters near Piacenza, resulting in 'the cutting off of all supplies from every quarter, save such as were brought up the Po in ships'. Polybius (3.57) records a similar story. Pliny (*Natural History* 3.123) claimed the river 'carried up it all the products of the seas', and Saint Ambrose (*Hexameron* 2.3.12), writing in the fourth century, called the Po, 'a trusty conveyer of maritime produce for the support of Italy'.

groups of amphorae and other ceramics have been recovered from rivers, but their context is often unrecorded or uncertain.⁸⁶ The cargo of the Stella I wreck forms the most complete assemblage recovered so far.⁸⁷ This barge was carrying a shipment of at least 120 roof tiles (*imbrices* and *tegulae*), produced by local suppliers along the River Stella.⁸⁸ Several Dressel 2-4 and Lamboglia 2 amphorae were also recovered from the wreck, although it is unclear whether these formed part of the cargo or were for use by the vessel's crew. The remains of the Stella I are complemented by the additional discovery of three stone cargoes from across the region (see Table 3.4). In all cases, the actual remains of the wreck have disappeared, leaving only the remains of the cargo in situ. The largest of the three stone cargoes comes from the Bacchiglione wreck, comprising two sets of column bases and column drums, located at the bottom of the Bacchiglione River. The unfinished nature and homogenous grouping of the two sets make it more likely that they formed a cargo as opposed to having been part of a bridge or building adjacent to the river (see Figure 3.21).⁸⁹ The Bacchiglione wreck's cargo of stone was 17 tonnes and considering the distribution of the remains it seems likely the ship was carrying additional cargo, perhaps perishable, that has since been salvaged or decayed.⁹⁰ The stone was Euganean trachyte from quarries located less than 10 km from the wreck site, which saw common use in Roman construction across Northern Italy (see Section 8.1).⁹¹ Elsewhere the San Basilio di Ariano Polesine wreck in the delta area was found to be carrying two blocks of limestone from Domegliara near Verona, while the Como wreck's cargo consisted of a 16-tonne load of shaped Musso marble.⁹²

The surviving wreck evidence shows a wide variety of craft were active on Northern Italy's water network during the Roman period. The waterways were used by vessels designed solely for inland use and those that could engage in both fluvial and maritime environments. The recovered vessels served a mix of purposes, with wrecks such as the Bacchiglione and Stella I suggesting that significant loads were being transported on the riverscape. While the uneven distribution of the evidence allows limited insight into waterborne transport in the western reaches of the Po-Veneto plain, the extensive remains of port infrastructure uncovered in this area serve to complement the wrecks from the east of the region.

⁸⁶ Zucca (1996), 126.

⁸⁷ This is excluding the cargo of the Comacchio wreck, which was discovered in a maritime context. See Bondesan et al. (1990), for details on the cargo.

⁸⁸ Castro and Capulli (2016), 31.

⁸⁹ Previato and Zara (2014), 61-63.

⁹⁰ Previato and Zara (2014), 72.

⁹¹ Previato and Zara (2014), 71.

⁹² Dallemulle (1977), 123-24; Montalcini De Angelis D'Ossat (1993), 56.

3.1.5 Ports and Harbours

Cargo barges travelling on Northern Italy's water network would have required terrestrial infrastructure to allow the loading, unloading, and storage of their goods. The fluvio-maritime ports of Ravenna, Altinum, and Aquileia, which served as entry points for the inland water network, are well documented, with Aquileia one of the most complete surviving examples of a Roman riverport.⁹³ Further inland, the situation is more complex. The surviving textual sources indicate the navigability of the river network and its use to transport goods and people far into the valley (see Section 3.1). Unfortunately, many cities in Northern Italy that are linked to travel on the water network through ancient literature or epigraphy, lack archaeological evidence for a port (see Table 3.1). This is not to say that they did not exist, but rather they have been either lost to the erosional forces of the river or are buried too deep and yet to be discovered. There were probably far more ports than the surviving evidence suggests.

On the Po itself, there have been limited discoveries of ports or their associated structures. A minor structure that might be identified as a port installation was discovered at Lago Tramonto, a flooded gravel pit on a paleochannel of the river at Gambulaga, near Ferrara.⁹⁴ An underwater survey carried out by the Emilia-Romagna *soprintendenza* documented many Roman artefacts exposed by the collapse of the pit's walls, including a line of 11 wooden piles retaining a layer of compacted clay, thought to represent the northern bank of the Po during the second century AD.⁹⁵ The quay at Lago Tramonto is complemented by the discovery of a large *horreum* adjacent to the Po in Turin, which the excavators hypothesised was linked to the city's river port (see Figure 3.22).⁹⁶ However, no other traces of port infrastructure, such as embankments or wharfing, have been discovered. There is more extensive evidence for ports on the tributaries of the Po and rivers of the Venetian plain, but even this is limited when compared to the supposed extent of navigable rivers in the Roman period. Table 3.5 compiles the current surviving archaeological evidence for river ports in Northern Italy (see Figure 3.23 for locations).

Within Northern Italy, many cities were not located directly on a riverfront, either to avoid flooding, or because the channel had subsequently moved away, necessitating the construction of a channel to link the city with the river network. In the south-west of the valley at Tortona, a short canal connected the city's port

⁹³ See Bertacchi (1980); (1990); Grazia Maioli (1990); Mozzi et al. (2016).

⁹⁴ Bucci (2015), 55. The pit was dug during the 1980s on a paleochannel of the Po after the practice of extracting gravel from the active riverbed was outlawed (see Section 2.1).

⁹⁵ Bucci (2015), 59. Several monoxyls were also recovered from the site (Bucci (2015), 57-58; (2018), 11-16).

⁹⁶ Barrico and Subbrizio (2007).

Site	Date	Embankment/ Wharfing	Fluvial Canal	Additional Infrastructure	Publication
Brescia	Fifth Century AD (Possibly replacing an earlier structure)	Stone	Yes	<i>Horrea</i>	Cavaliere Manasse (1990); Mirabella Roberti (1961); Ruggiu Zaccaria (1969)
Corte Cavanella	First Century BC	Wooden	Yes	Boathouse	Sanesi et al. (1985); Sanesi et al. (1986)
Industria	First Century AD		Yes		Zanda (2011)
Ivrea	Mid First Century AD - Early Second Century AD	Stone		<i>Horrea</i>	Brecciaroli Taborelli (2007); Finocchi (1980)
Julia Concordia	First Century BC - First Century AD		Yes	<i>Horrea</i>	Rousse (2013); Vigoni (2006)
Lago Tramonto	Second Century AD	Wooden			Bucci (2015); (2018)
Lake Garda	Roman			Jetties	Massensini (1973); Uggeri (1990)
Milan	First Century BC - First Century AD	Stone and Wooden	Yes	<i>Horrea</i>	Caporusso (1990); (1991a) Frontori (2017)
Oderzo	Early First Century AD	Stone		Waterwheel	Cipriano and Sandrini (2001); Malizia (1986); Tirelli (1987)
Padua	First-Second Century AD	Stone and Wooden			Balista and Ruta Serafini (1993); Uggeri (1990)
Piacenza	Third Century BC - First Century BC		Yes		Cera (1995); Pagliani (1991)
Testona	Late Roman	Wooden			Pantò and Occeffi (2009)
Tortona	Late First Century AD - Early Second Century AD	Stone	Yes	<i>Horrea</i>	Crosetto (2013a); Venturino Gambari et al. (2011)
Turin	Late First Century AD - Third Century AD			<i>Horrea</i>	Barrico and Subbrizio (2007)
Vercelli	First Century BC	Stone	Yes	<i>Horrea</i>	Panero (2013); Spagnolo Garzoli et al. (2007)

Table 3.5: Port infrastructure dating to the Roman period discovered in Northern Italy.

with the Torrente Scrivia. The canal was formed by diverting part of the Scrivia closer to the city during the first century AD and was re-excavated during the third century.⁹⁷ The port itself consisted of two long masonry docks lining either side of the canal, the channel of which was 9 m wide (see Figure 3.24).⁹⁸ The dock walls were 1 m wide and constructed of river pebbles and concrete, being reinforced with buttresses every 10 m to anchor the structure to the banks and counteract lateral thrust from the river. A comparable structure exists on the River Sesia, where the remains of a canal constructed in the first century BC linking the river to Vercelli were discovered. The canal was 11 m wide and 2 m deep, with its sides reinforced by stone retaining walls (see Figure 3.25).⁹⁹ To the east in Milan, a complex network of canals flowed through the city to connect it with the Lambro. This relied on the diversion of the Olona, which eventually flowed out towards the Lambro through the *Canale Vettabbia*, a channel that united the majority of waterways within the city.¹⁰⁰ Finally, at Brescia, on the foothills of the Alps, it seems probable that either the Garza, Mella, or Chiese were chan-

⁹⁷ Crosetto (2013a), 102-8. The wharfing was exposed for a length of 68 m, though likely continued beyond the excavation area.

⁹⁸ Crosetto (2013a), 101-102; Venturino Gambari et al. (2011).

⁹⁹ Spagnolo Garzoli et al. (2007), 112; Panero (2013).

¹⁰⁰ Caporusso (1991a), 94-96; Cera (1995), 179. Several sections of Roman canal have been excavated within the city. At San Lorenzo, a section of brick lined, 4 m wide canal was discovered, and at Seveso and Porta Romana, stretches of docks have been found.

nelled to connect the city more directly with the Oglio and the Po.¹⁰¹ Evidence for canals connecting cities to the Po also exists at Industria and Piacenza.¹⁰²

Urban areas contained the most substantial port infrastructure and river wharfs have been discovered in cities across Northern Italy. Wharfing was primarily constructed on a foundation of timber piles, with the main structure formed of a concrete core faced in stone on its riverward side. One of the best surviving examples of this comes from Ivrea, where a 100 m long stretch of wharf was uncovered at during a flood of the Dora Baltea, in 1977 (see Figure 3.26).¹⁰³ In Milan, the MM3 and several earlier excavations uncovered several sections of wharfing situated along this canal running to a combined length of approximately 250 m, constructed in a similar manner to that discovered at Ivrea (see Figure 3.27).¹⁰⁴ This was complemented by the remains of a large basin, set beside the canal.¹⁰⁵ At Brescia, a section of quay thought to date from the fifth century AD was discovered beneath the via Mantova, to the south-east of the city walls.¹⁰⁶ The exposed section of the quay ran for 24 m and was constructed from blocks of Botticino marble, recycled from a large funerary monument (see Figure 3.28).¹⁰⁷ The structure seems to be a reconstruction or relocation of an earlier port installation. At Padua, a small section of wooden wharfing was uncovered on the banks of the Bacchiglione, abutting the city walls.¹⁰⁸ More substantially, in the

¹⁰¹ Cera (1995), 192-93.

¹⁰² At Industria, the path of the port canal is marked by a 16 m wide depression linking the city to a paleochannel of the Po (Zanda (2011), 42). The evidence for a canal at Piacenza (termed the *Fossa Augusta di Piacenza*), is somewhat more circumstantial (Cera (1995), 182-83; Pagliani (1991), 78, note 228). There was certainly a medieval canal in the area of the modern Torrione Fodesta, which is attested to in documentation from 1209 onwards and the remains of which were found during an excavation in 1958. It has been suggested that the medieval names of *Forusta* and *Fodesta* used in this documentation represent an evolution of Fossa, consequently linking back to the *Fossa Augusta di Piacenza*. The reason for the construction of this canal was likely the Po shifting its course to the north away from the city between the third and first centuries BC (Marchetti and Dall'Aglio (1990), 604-40).

¹⁰³ Brecciaroli Tadorelli (2007), 133; Finocchi (1980), 89-90. Finds from the excavation dated its construction to the mid-first to early-second century AD (Cera (1995), 186). Upstream from the wharf, the Dora Baltea passes through a narrow gorge, with the channel being further constricted by the Ponte Vecchio, a bridge constructed during the Roman period. Given the narrow width of the channel at this point, it may be that the wharf at Ivrea marked the navigation limit for the Dora Baltea in the Roman period, at least to conventional vessels.

¹⁰⁴ Caporusso (1990), 94, (1991a), 245; Frontori (2017), 41-44, 93-97, 109-13. The remains were discovered in the via Baracchini, the via S. Clemente, the via Ore, the Via Larga, and in the Porta Romana area. The quay itself seems to have been constructed during the Augustan period, and finds of ARS suggest it was active until at least the end of the fifth century AD (Caporusso (1991a), 246).

¹⁰⁵ Caporusso (1990), 96; (1991a), 246.

¹⁰⁶ The dating of the port itself is uncertain. Although the original excavator suggested a Severan date for its construction, a strong case has been made for the fifth century AD based on other reuse of monumental funerary architecture in Lombardy (Mirabella Roberti (1961), 272-80; Ruggiu Zaccaria (1969), 144-46).

¹⁰⁷ Cavaliere Manasse (1990), 11-12.

¹⁰⁸ Balista and Ruta Serafini (1993), 110. While its primary function was to prevent the un-

area near the University and the Café Pedrocchi, close to the paleochannel of the Bacchiglione, several ramps were discovered that linked the ancient street level to the lower wharfs on the riverbank below (see Figure 3.29).¹⁰⁹

Port infrastructure did not stop at the wharfs but extended into the area immediately behind the riverbank and (at times) into the river itself. At Oderzo, a section of wharfing on the Piave, abutting an area of riverbank reclaimed by an amphora deposit, was discovered during the 1980s (see Figure 3.30).¹¹⁰ Abutting the quay were the remains of several dolphins (clusters of wooden pilings) used to moor boats and protect the quay from impact (see Figure 3.31).¹¹¹ On Lake Garda, the remains of a set of wooden jetties at Padenghe sul Garda were also discovered (see Figure 3.32), however the poor state of the remains means little could be inferred other than that they dated to the Roman period.¹¹² In the majority of instances where wharfing survives, it has been accompanied by the discovery of *horrea* in areas adjacent or immediately behind the structure (see Table 3.5. *Horrea* formed an integral part of dockside infrastructure, enabling the storage of cargo prior to its loading or redistribution.

Away from urban areas, there were smaller rural ports and landing sites, although the evidence is much patchier. The site of Corte Cavanella has already been mentioned above in relation to its accompanying wrecks. The villa and boathouse was located a short distance from a canal, its banks reinforced by wooden stakes, which remained active into the fourth century.¹¹³ At Lago Tramonto and Testona, small stretches of wooden wharfing extended along the riverbanks.¹¹⁴ While these sites could certainly have served as landing stages for smaller watercraft, it is also possible that their main purpose was, in fact, to protect the bank itself from erosion and undermining.¹¹⁵ While the facilities at Corte Cavanella, Lago Tramonto, and Testona perhaps only served an individual

dermining of the city walls by the river, it has been hypothesised the structure also functioned as a quay.

¹⁰⁹ Uggeri (1990), 184.

¹¹⁰ Cipriano and Sandrini (2001); Malizia (1986); Tirelli (1987).

¹¹¹ Cipriano and Sandrini (2001), 291. The area of the river above the quay seems to have been repurposed in the second century AD, when a rubble-filled wooden formwork was laid across the river. This blocked upstream navigation beyond the river port, and a wooden water wheel was installed upon the barrage, alongside other supporting infrastructure (Trovò (1996), 130-32).

¹¹² Massensini (1973), 44-47; Uggeri (1990), 185. It is also possible that port structures existed near Sirmione, at the Grotte di Catullo, however these were destroyed during the Second World War (Cera (1995), 196). The lake would have been linked into the water network by the River Mincio, which forms a tributary of the Po. The *Collegia Nautarum* active on the lake and the river have been discussed above, but the journey upriver to the lake is also alluded to by Catullus (4), when he describes taking his boat ‘from a foreign sea, here, as far as this limpid lake’.

¹¹³ Sanesi et al. (1985), 15-16, 19-20; Sanesi et al. (1986), 25-27.

¹¹⁴ Bucci (2015), 59; Pantò and Occelli (2009), 228.

¹¹⁵ Page (2021), 9-13.

site, they demonstrate that smaller settlements were still investing in facilities to access the water network.

The archaeological evidence has shown there was widespread and significant investment in port infrastructure across Northern Italy from the first century AD onwards. The size and scope of the surviving port network in the region suggests navigation was possible on the Po and many of its tributaries to a point well beyond current limitations. Indeed, the construction of significant port infrastructure at Ivrea, some 545 km upstream from the modern mouth of the river, suggests that the water network offered far reaching connections into distant areas of the region. Overall, the surviving textual, epigraphic, and archaeological evidence paints a picture of a sophisticated transport network in place on the waterways of Northern Italy. From ferries to cargo barges, goods and people moved up and down the river in a variety of ways. This was complemented by considerable terrestrial infrastructure, the docks and warehouses necessary for the safe transfer of cargo from vessel to shore and vice versa. However, the waterways formed only one half of the transport network present within Northern Italy. Not all settlements were on the waterways, and no river was navigable all the way to its source. It was here that the roads of the region acted to connect the areas not accessible by water, and, at times, offered an alternative itinerary.

3.2 The Road Network

Overland transport has often been assumed to be too expensive or too impractical for the carriage of heavy goods over long distances during the Roman period.¹¹⁶ Water transport, either fluvial or maritime, was promoted as preferential in all circumstances, exemplified by Horden and Purcell's remark that all roads reflected 'the shortest distance between two prominent seamarks or navigable rivers'.¹¹⁷ However, this position has been revised over the past two decades, with the growing realisation that fluvial and terrestrial transport necessarily had to work in tandem with one another.¹¹⁸ The role that roads played has been underestimated, in particular their essential part in connecting areas not reachable by water.¹¹⁹ In some circumstances, it may have been preferential to transport cargoes solely by road rather than utilise available waterways. Heavy, fragile, and high value cargoes with the potential for a high wastage rate, for example shaped marble,

¹¹⁶ The origin of this movement of thought and the development of scholarly thinking on the issue of overland transport has been extensively covered elsewhere. Laurence ((1999), 95-108) contains a good summary of twentieth century thinking on the issue. See also Raepsaet (2009).

¹¹⁷ Horden and Purcell (2000), 126.

¹¹⁸ Adams (2012), Campbell (2012), 215-17; Laurence (2005), 138.

¹¹⁹ Hitchner (2012); Quilici (2009); Raepsaet (2009).

were unwieldy to load and transport. Transshipment between road and water increased the likelihood of damage to the cargo, or in extreme cases its loss entirely (stone elements submerged in a river are difficult to recover, as demonstrated by the Bacchiglione wreck).¹²⁰ Transporting the cargo by the same method for the entirety of its inland journey would have minimised the risk, even though it may ultimately have proved more expensive.

The road network could often provide more direct connections between destinations than the water network. Where the roads climbed into the mountains, they were forced to follow the path of the river valleys, but the roadways on the plain had no such constrictions. The flat, even ground was perfectly suited to overland travel and while potentially slower, offered a shorter route than the meandering path of the rivers in many cases. This was especially true between cities along the foothills of the Alps and Apennines, where riverine connections existed north-south as opposed to east-west. For example, the overland journey between Verona and Brescia is 71 km, whereas as a river journey down the Adige, up the Po, and then up the Oglio was approximately 430 km.¹²¹ The long upriver segment of this journey (some 300 km) would also have added considerably to the difficulty and cost of its use. The road network was also less weather-prone than other forms of transport. While there was an element of seasonality to the roadways, this was to a far lesser extent than the river network (see Section 2.2.3). Although winter rain might turn an unpaved road surface into impassable sludge or snow block mountain passes, many stretches of the network could still be used under the right conditions. Roads were often placed above the level of hydrological hazards and were well drained, often being flanked by large drainage channels/canals.¹²² While not always guaranteed to work (see the flooding of the via Emilia near Modena below) the roads could provide a safer alternative to the often-treacherous winter river regime. Furthermore, as river conditions became more turbulent from the third century onwards, the road network may have become an increasingly important alternative to fluvial travel.

3.2.1 Development of the Road Network

In some respects, the development of the road network is easier to track than that of the water network, with the construction of the major consular roads well-documented by Livy. These main routes were complemented by a system of smaller roads that connected towns, villas, farms, and other sites across the countryside. Most are not named, but their routes are attested to by the *Antonine*

¹²⁰ Russell (2013), 104-05.

¹²¹ Distances based on the network model in Chapter 4.

¹²² Botazzi (1992), 173-75; Ortalli (1992), 57-58.

Itineraries, the Peutinger Table, milestones, and the discovery of their remains in the archaeological record. There have been attempts to reconstruct the path of these roads, however only an approximation of their route can be traced in the landscape.¹²³ The construction dates of many minor roads are unknown and their full development, alongside the true extent of the full road network, will probably never be known.¹²⁴ Regardless, it is possible to sketch out a broad picture of the development of terrestrial transport routes in the region from the surviving evidence.

Roman expansion into Northern Italy began in the third century BC. This was set against a backdrop of road construction in Central Italy, which included the via Flaminia (completed in 220 BC).¹²⁵ The via Flaminia connected Rome and the colony of Ariminum and provided a jumping off point for the development of the road network across the Po-Veneto plain. Roman interests in the area were cemented by the foundation of colonies at Piacenza and Cremona by 218 BC, which would be followed by several decades of regional turmoil that included the Second Punic War and the revolt of the Boii and Insubres.¹²⁶ In 187 BC, the via Aemilia was constructed, linking Piacenza and Ariminum.¹²⁷ The 180s would see a spate of colony building along the line of this road, including Bologna (189 BC), Modena (183 BC), Reggio Emilia (183 BC), and Parma (183 BC).¹²⁸ Another branch of the road, the via Aemilia Lepidi, would connect Bologna and Altinum. The via Postumia would be constructed by 148 BC, connecting Aquileia to Genoa and passing through the important centres of Verona and Cremona. The via Popila, constructed in 132 BC, and the via Annia, constructed in 131 BC, would create important north-south links along the Adriatic coastline, connecting Aquileia, Padua, and Adria with Ariminum (see Figure 3.33).¹²⁹

The road building of the second century BC formed the backbone of the terrestrial transport network in Northern Italy. This would be further expanded in the late first century BC and first century AD, as the development of the

¹²³ For example, Bosio (1991) and Pellegrini (2004). Both use a combination of archaeological and epigraphic evidence to map Roman roads in the Eastern North Italy and Istria. See also the *Barrington Atlas of the Ancient World* (Talbert and Bagnall (2000)).

¹²⁴ For example, the recent discovery of a roadway submerged within the Venetian lagoon points to a more extensive network in this part of the region than had previously been imagined (Madrucardo et al. (2021)).

¹²⁵ Livy, 20.17; Laurence (1999), 21-25. Many of roads discussed here likely followed the paths of pre-existing connections between places (Hitchner (2012), 223).

¹²⁶ Livy, 21.25, 21.56, 38.11; Polybius 3.61-71.

¹²⁷ Livy, 39.2. Only five milestones are dated to the Republican era in Northern Italy. These correspond to the via Aemilia, the via Postumia, and the via Popila, and confirm Livy's dating for the construction of these roads (Basso (2008), 69).

¹²⁸ Livy, 37.57.

¹²⁹ Pellegrini (2004), 44; Quilici (2009), 558; Veronese (2011).

region continued.¹³⁰ The foundation of new colonies by Augustus in the far west of the valley, such as Aosta and Turin, necessitated the creation of new roads. In the Aosta valley especially, significant construction was undertaken to connect the important route over the St. Bernard Pass into the wider road network.¹³¹ Other notable works during the Augustan period included the creation of the via Iulia Augusta and the repair of the via Aemilia between Ariminum and the River Trebbia.¹³² Many of the region's waterways were also bridged in stone for the first time during this period.¹³³ Furthermore, as the road network grew, pre-existing sections were expanded to accommodate changing vehicle size and increasing traffic. The widening of some roads has been noted; for example, the via Aemilia to the east of Modena was increased from 4.5 m to 6 m in width during the Early Imperial period.¹³⁴ Northern Italy's position as a transition zone between Southern and Northern Europe, coupled with the consolidation of Roman expansion in Gaul and Germany, also resulted in the creation of new transalpine roads to connect Italy with the northern provinces. A new road along the banks of Lake Como was constructed during the late first century BC, and the via Claudia Augusta, begun by Drusus the Elder, was completed by Claudius c. AD 46-47.¹³⁵

By the end of the first century AD the road network seems to have reached its full extent, seeing little notable expansion beyond this point. Alterations or expansions to the network are harder to track from the second and third centuries AD than in the preceding centuries.¹³⁶ For example, the via Iulia Augusta seems to have seen extensive repairs under either Antoninus Pius or Caracalla. There is also evidence for the creation of several *collegia iumentariorum* (muleteers) in the region during this time (see Table 3.6).¹³⁷ The connection with specific city gates, for example the Porta Ioviae and Porta Vercellinae in Milan, suggests that some *collegia* operated or had expertise along specific routes.¹³⁸ Echoing the foundation of *collegia nautarum* the waterways, this reflects an increasing level of organisation and sophistication in the journeys being undertaken on Northern

¹³⁰ Twenty-four milestones in Northern Italy date from this period, with the main emperors recorded being Augustus, Claudius, Vespasian, and Titus (Basso (2008), 69).

¹³¹ Lucchese (2004), 22; Mollo Mezzana (1992), 70.

¹³² Seventeen milestones can be attributed to Augustan construction or repairs. Augustus' repair of the via Aemilia is recorded on a milestone in Bologna (CIL XI.8103 = ILS 9371; Basso (2008), 69).

¹³³ Cera (1996), 193; Marini Calvini (1999), 187; Quilici (2009), 571.

¹³⁴ Labate (2019), 198.

¹³⁵ CIL, V.8002 = ILS, 208; Bonora Mazzoli (1992), 54; Bosio (1991), 133-47.

¹³⁶ For example, the via Iulia Augusta seems to have seen extensive repairs under either Antoninus Pius or Caracalla (Basso (2008), 69).

¹³⁷ Data from the Epigraphik-Datenbank. https://db.edcs.eu/epigr/epi_ergebnis.php (Accessed 15/12/2021).

¹³⁸ Laurence (1999), 134; Perry (2016), 507.

Find Spot	Inscription	Date	Reference
Brescia	<i>Gen(io) coll(egii) / [i]umentarior(um) / [3]amia Firmia / [T]ertia [3] / [3]iob() C[Vol<>an(o) Aug(usto) / P(ublius) Antonius / Callistio VI/vir Aug(ustalis) et C(aius)</i>	Unknown	CIL V.4211 = AE 2007, 576
Brescia	<i>Clod(ius) / Comicus et P(ublius) Post(umius) / Agatho idem / sport(ulis) dedic(averunt) et in / tutel(am) HS CCCC ded(ederunt) / coll(egio) iument(ariorum) (c)ollegium (iu)mentario(rum)</i>	Unknown	CIL V.4294 = AE 2007, 576
Milan	<i>Portae (Ve)rcellinae (e)t Iovae</i>	Unknown	CIL V.5872
Rosegaferro	<i>D(is) M(anibus) / permiss(u) manc(ipum) / iumentarior(um) / port(ae) Iov(iae) / [3]sosius / [3]ussem / [3]urno / V(ivus) f(ecit) / Q(uintus) Spurius Senecio / sibi et Q(uinto) Spurio / Secundo fil(io) et / Spuriae Augustinae / filiae ex permissu</i>	AD 117 - 138	AE 1975, 429 = AE 2007, 576 = AE 2010, 53
Verona	<i>colleg(ii) / iumentarior(um) port(ae) Iov(iae)</i>	AD 100 - 200	AE 1987, 552 = AE 2010, 53

Table 3.6: Inscriptions relating to *iumentariorum* and *collegia iumentariorum* in Northern Italy.

Italy's road network during this time.

Moving into the third and fourth centuries AD, most evidence for investment and maintenance in the road network comes from milestones. Some 185 of the 250 milestones in Northern Italy date from between the end of the third century and the beginning of the fifth century AD.¹³⁹ Even accounting for the possibility that many earlier milestones are missing due to their destruction or reuse, this figure seems high. It is possible that the large increase in milestones reflects repair work undertaken on the roads during this time. For instance, a string of milestones between Aquileia and Torvicosa refer to the repairing of roads and bridges between AD 235 and 238.¹⁴⁰ The greater importance and militarisation of the region during this later period, coupled with the need for quick and efficient transport links in a critical area, could also account for the increase.¹⁴¹ However, the increase in milestones may also reflect their changing purpose. Surviving milestones from the tetrarchy onwards often do not record the number of miles, but rather contain honorary language and dedications towards the emperors.¹⁴²

¹³⁹ Basso (2008), 69.

¹⁴⁰ CIL V.7989; CIL V.7990; AE 1979.256; AE 1979.257.

¹⁴¹ Basso (2008), 68; Buonopane and Grossi (2014), 166. Franconi ((2014), 54) theorises that the increase in milestones commemorating repairs during this period could reflect a greater drive to repair roads in response to changing climatic conditions. Increased rainfall and flooding may have led to the degradation of sections of the road network, and as fluvial regimes became less suitable for travel, its maintenance increased in importance.

¹⁴² Basso (1987), 80-90; (2011), 67. The relative uniformity of the milestones from the first and second centuries disappears, with a variety of shapes, sizes, and stone types used. Some milestones were even created using imported coloured marble or from architectural elements such as columns, to monumentalise the markers.

Indeed, in times of turmoil it is not uncommon to see milestones altered in rapid succession in an effort to keep pace with current politics, as is seen on a string of milestones from modern Veneto which were recarved to honour the emperors Valentinian, Valens, and Gratian over a five-year period.¹⁴³ Consequently, the large increase in milestones during the third-fourth centuries may not always represent new investment in the road network, but rather reflect the new role milestones played as a medium for local administrators to publicly display loyalty to the emperor.¹⁴⁴ Even so, the choice of milestones as a canvas for these messages suggests there was still significant traffic using the roadways during this time, attesting to their continued importance during this later period.

By the end of the first century AD, the road network provided terrestrial connections between the lowlands of the coastal regions and the high mountain passes of the Alps, accessing areas the water network could not. They connected the region to the rest of the Italian peninsula on the other side of the Apennines, and the northern-western provinces across the Alps. The system does not seem to have been significantly expanded beyond the end of the first century AD, although repairs and modifications would be continuously carried out. The road network maintained its importance throughout Late Antiquity and would continue to help dictate the main axes of travel within Northern Italy beyond this point. However, the breadth and scale of the terrestrial transport network could not have been achieved without huge investment in infrastructure, at times quite technical, to overcome various obstacles and hazards present within the region.

3.2.2 Infrastructure

Long-distance overland journeys presented an array of topographical obstacles and challenges to transport (discussed above), many of which could be reduced or bypassed entirely through the construction of supporting infrastructure. Across Northern Italy archaeological investigation has shown the great lengths the Romans went to in optimising conditions on the roads. Cuttings, embankments, and bridges brought the road network from the floor of the plain high into the Alps, Apennines, and beyond. The survival of many of these structures to the modern day, and in some cases their continued use in the post-Roman period, attests to their strength and the skill involved in their construction.

Where roads were paved in the east of Northern Italy, the material of choice was often Euganean trachyte, a hard-wearing and exceptionally durable stone, found in the cargo of the Bacchiglione wreck, as noted above. Quarried in the

¹⁴³ For example, ILS 675, CIL V.8031; CIL V.8032. See also Zanetti (2011), 118-21.

¹⁴⁴ Basso (2018), 107; Buonopane and Grossi (2014), 162-64. See also Sauer (2013), for an Empire-wide discussion of this phenomenon.

Euganean hills to the north-west of Padua, the stone was transported widely along the road and water network (see Figure 3.34).¹⁴⁵ One of the necessities of using this stone was in part due to a lack of suitable alternatives elsewhere in the region. While local stone was used where possible, on the Apennine side of the Po valley especially, the local geology is near uniformly limestones and sandstones, too soft for road paving.¹⁴⁶ Mid-level roads in areas close to watercourses often used river pebbles to form a cobble surface.¹⁴⁷ Of course, many roads were not paved at all, such as the axial roads of the centuriation grids that crisscrossed the landscape.¹⁴⁸ While in many cases this was due to the minor nature of the road and expense involved in paving it, at times this seems to have been practical choice. For example, when the Alpine roads began to move into the passes, their paved surfaces often switched to that of a beaten earth track or cut directly into the rock for large sections.¹⁴⁹ In view of the destructive hazards of the Alpine passes, particularly avalanches, a more easily altered and repaired road surface seems to have been favoured over the monumentality seen on their lower approaches.¹⁵⁰

Down on the valley floor, the wide, level plain provided efficient transport connections north-south and east-west. However, while the flat, low ground allowed swift travel on a near even gradient, the marshy ground of the lower areas of the Po-Veneto plain would have caused difficulties for road construction, requiring technical solutions to overcome them. Any infrastructure following the valley floor would be vulnerable to the high-water table and extreme hydrological events. Indeed, the *via Aemilia*, in its stretch between Modena and Bologna, was submerged and at times seriously damaged by flood waters.¹⁵¹ Many roads were flanked by drainage channels, normally ranging between 1 m and 4 m in width, with some of the largest examples reaching 7 m.¹⁵² The widest channels may also have functioned as canals, allowing the road to double as a towpath. In an effort to combat the high-water table and guard against subsidence, one section of the *via Aemilia* outside Parma was constructed entirely atop a reclamation deposit of some 20,000 amphorae (see Section 6.1).¹⁵³ In other sections, wooden piling was used to create a foundation for the road surface and stabilise the ground for

¹⁴⁵ Germinario et al. (2018), 426-27; Previato and Zara (2018), 604; Zara (2018), 337-59.

¹⁴⁶ Marini Calvini (1999), 188; Ortalli (1992), 150.

¹⁴⁷ Marini Calvini (1999), 189.

¹⁴⁸ Botazzi (1992), 172.

¹⁴⁹ Bonora Mazzoli (1992), 54; Mollo Mezzana (1992), 59-65.

¹⁵⁰ Mollo Mezzana (1992), 66.

¹⁵¹ Labate (2019), 199. See also the burial of a major road between Bologna and Padua due to the flooding of the Reno in the late third century AD (Cremonini (2002); (2003)).

¹⁵² Botazzi (1992), 173-75. Varro (*de re rustica* 1.14.2-3) commented that it was common to see 'this type of enclosure ... built along public roads and along streams'.

¹⁵³ Marini Calvini (1999), 190-91.

heavier infrastructure.¹⁵⁴ In particular, piling is often seen in the foundation layers of bridges and bankside infrastructure in the region. For example, the Ponte Vecchio at Ivrea was constructed atop a bed of compacted oak stakes driven deep into the riverbed and consolidated with iron clamps.¹⁵⁵ A similar situation is seen in the foundations of a bridge on the path of the via Annia near Roncade, Treviso (see Figure 3.35).¹⁵⁶ In the low-lying areas near the lagoon system and the Po, it was sometimes necessary to physically raise the height of the roads above the level of flooding and tidal surges (see Section 2.3.2). This is seen on the via Annia, where the road runs atop an embankment for long stretches between Altinum and Aquileia, and also in the remains of the via Popilia where it runs near Adria (Figure 3.36).¹⁵⁷ Finally, it is worth noting that the risk of flooding was not solely limited to low land areas. In the Alpine valleys, flooding was also a prime concern for engineers in the Valle d'Aosta, where the level of the road between Ivrea and Aosta was kept well above the flood peak of the torrential Dora Baltea.¹⁵⁸

The heights of the Alps and the Apennines provided a different set of challenges to Roman engineers, in particular the gradient of the road surface. While the glacial valleys penetrated deep into the Alps, eventually gradient become more and more of an issue. The grade of a slope has a large impact on the efficiency and feasibility of its traversal. An incline of just 1% required double the number of haulage animals to move at the same speed as over level ground, and slopes of over 5% would likely have been impassable without specialist equipment for heavy loads.¹⁵⁹ This required technical expertise to overcome, with some of the best documented examples coming from the Valle d'Aosta. Here, a diverse range of bridges, cuttings, embankments, switchbacks, and viaducts were constructed to reduce the gradient and protect travellers from hazards on the road leading to the Great and Little St. Bernard passes. These included the 80 m cutting at Donnas, the retaining wall at Villeneuve, the embankment at Runaz, and the viaduct at Saint Vincent (see Figures 3.37, 3.38, 3.39, and 3.40). The road through the valley climbed 517 m between Donnas and Runaz, yet the average gradient was just under 7% and never exceeded 10%.¹⁶⁰ While the Valle d'Aosta contains some of the best-preserved examples of Roman incline engineering, similar examples are seen elsewhere in Northern Italy. In the hills flanking Lake Como, a road

¹⁵⁴ Calzolari (1992), 162.

¹⁵⁵ Brecciaroli Taborelli (1987a), 147-48; (2007), 130-33.

¹⁵⁶ Busana (2008), 30-31.

¹⁵⁷ Calzolari (1992), 165; Papisca (2010).

¹⁵⁸ Mollo Mezzana (1992), 57.

¹⁵⁹ Raepsaet (2009); Russell (2018a), 139.

¹⁶⁰ Mollo Mezzana (1992), 57; 62.

was cut through the steep terrain which contained cuttings at regular intervals along its surface, designed to help travellers and beasts of burden cope with the steep gradient, and at Pieve di Tolmezzo in the Tagliamento valley, an 80 m long cutting allowed the via Julia Augusta to follow a level path parallel to the river.¹⁶¹

In a landscape dominated by water, bridges formed a vital component of most roads in Northern Italy. Many were constructed in stone or mixed materials, with roads such as the via Aemilia and via Annia returning evidence for dozens of bridges along their length.¹⁶² Despite this, there is little surviving evidence of bridges constructed on the Po itself. It is possible that bridges on the Po may have been built in wood, accounting for their lack of survival in the archaeological record, or that circumstances similar to those affecting the paucity of inland wreck discoveries also apply to bridges (see Section 3.1.4). However, the width of the river, combined with its high volume of discharge and variable path, may have made a permanent structure impractical, especially in the lower reaches of the river. Indeed, the only surviving bridge remains come from the Upper River, at Brusasco near Industria, where the river is less than 150 m in width and the mean discharge rarely exceeds 160 m³/s.¹⁶³ The difficulty of bridge building in the Middle and Lower Po necessitated other ways of crossing the river. Contemporary ancient writers make references to pontoon bridges, often in the context of military campaigns. During the Second Punic War, Cornelius Scipio constructed a pontoon bridge across the Po at Piacenza, retreating across it after being defeated in a skirmish near Pavia. His destruction of the bridge in the aftermath temporarily stranded Hannibal's troops on the north bank, forcing them to take a lengthy detour west to find another crossing point.¹⁶⁴ Later, during the civil war of AD 69, Tacitus records the construction of a pontoon bridge on the Po by Vitellius, as his forces tried to attack Otho's troops near Cremona.¹⁶⁵ However, the military setting of such encounters suggests these were not permanent features on the riverscape but were constructed as and when needed. Not only would they have been vulnerable to storm and flood damage, but they also would have impeded water transport up and down the river. It seems likely then, that in the absence of bridges, ferries were used to cross the river,

¹⁶¹ Bonora Mazzoli (1992), 54; Bosio (1991), 129.

¹⁶² See Bosio (1991); Calzolari (1992); Catarsi (2007); Cera (1996); Fozzati and Papotti (1996); Labate (2019); Lucchese (2004); Marini Calvini (1999); Ortalli (1992).

¹⁶³ Fozzati and Papotti (1996), 216. Sidonius Apollonaris *Epistles* 1.5.3, in the fifth century AD observed that most bridges in the region were constructed on sections of rivers that were not navigable, perhaps helping to account for the lack of evidence for permanent crossings below Turin on the Po.

¹⁶⁴ Livy, 21.47.

¹⁶⁵ Tacitus, *Histories* 2.34. See also, Plutarch, *Otho* 10; and Procopius, *History of the Wars* 6.12.30-31 for other military uses of pontoon bridges on the Po.

such as the one directly mentioned by Seneca and alluded to in the activities of other aforementioned writers (see Section 3.1.3).¹⁶⁶ It is also possible that a stela from Augusta Bagiennorum represents a ferryman (see Figure 3.41).¹⁶⁷ Finally, it is worth highlighting that bridges are obviously highly technical and expensive feats of engineering, and away from major roadways, ferries may have provided the only means of crossing isolated stretches of the water network.

While the Po itself seems unlikely to have been bridged for large stretches of its course, there is more evidence for bridges on its tributaries and other waterways within Northern Italy. Substantial remains have been found on the Adige, the Bacchiglione, the Dora Baltea, the Reno, and the Trebbia, to give some examples.¹⁶⁸ It has been noted that some bridges crossing the waterways of the Po-Veneto plain are designed differently from those found elsewhere in the Roman world. In the Veneto especially, Cera has shown that bridges, for example the Ponte Pietra in Verona, the S. Lorenzo and Altinate bridges in Padua, and the Ponte degli Angeli in Vicenza, utilised a much wider arch with a shallower angle than was normal (see Figures 3.42 and 3.43).¹⁶⁹ Reducing the number of pylons subjected to the strong currents of the river would have reduced stress on the structure and created less of an impediment to river traffic passing beneath the bridge.¹⁷⁰ Furthermore, the wide, low arches would have created a shallower gradient for those climbing onto the bridge to cross, an important consideration in the flatter areas of the plain where the height of the roadway on the bridge have been elevated above ground level. Of course, some bridges were positioned on non-navigable waterways. This is evidenced by their low and narrow arches – impassable to waterborne traffic – such as those seen on the Ponte delle Barche on the Retrone, Vicenza (see Figure 3.44).

Roman engineering allowed the road network to overcome high water tables, steep inclines, rivers, and marshes, enabling routes to extend into remote areas of Northern Italy. Without the creation of extensive infrastructure, overland travel would have been more difficult and labour-intensive, and in some areas, particularly in the low-lying, waterlogged parts of the plain and the mountainous reaches of the Alps and Apennines, the transportation of heavy loads may have been impossible.

¹⁶⁶ Seneca, *De Beneficiis* 6.19.

¹⁶⁷ CIL V, 7679. Medas (2018), 149.

¹⁶⁸ Brecciaroli Taborelli (2007); Catarsi and Dall’Aglia (1997); Cera (1996); Fozzati and Papotti (1996).

¹⁶⁹ Cera (1996), 179. Similar designs can also be seen in the remains of the two Roman bridges at Ivrea (Brecciaroli Taborelli (2007), 131-33).

¹⁷⁰ Cera (1996), 190-91.

3.3 Conclusions

The surviving evidence from Northern Italy's water and road networks demonstrates the presence of an extensive and well-integrated dual transport system. Working in tandem, rivers and the roads connected the coast to the mountains, the region to the rest of Italy and its northern provinces, and created the necessary links to transport goods and people efficiently between them all. The level of organisation is reflected by the presence of *collegia* involved in the transport of goods both overland and on the water. While the road and water network were in use from the mid-Republic onwards, the first century AD saw massive investment that upgraded existing structures and added new ones. The fact that certain elements of the network saw continued use in the post-Roman era points to its resilience and durability, alongside its ongoing influence over regional travel.

In a landscape where water formed a major part of everyday life it is unsurprising to see the high level of investment in and development of the riverscape. The water network was used extensively, and the combination of navigable rivers and manmade canals offered unprecedented coverage of the region. Literary accounts and wrecks recovered from Northern Italy point to both material and human cargo moving from the coast inland and vice versa. The large ports attached to the region's urban centres, alongside smaller installations at rural sites, allowed goods to be transported to consumption centres directly by water. Urban centres acted as nexus points in the network, allowing interaction between water and terrestrial transport, and the transferal of goods and people between the two.

While Northern Italy's waterscape saw significant use during the Roman period, this was in tandem with the road network. The great consular roads of the second century BC formed the system's backbone, which soon expanded to include a range of other routes and pathways. The road network allowed more direct connections to be made between the region's urban centres, alongside the redistribution of goods and people to areas not connect by the water network. Significant investment was made to overcome topological obstacles in the region and protect the roadway from hydrological hazards. Although all aspects of the network would have been subject to a degree of seasonality, investment in infrastructure would have helped to keep routes open and goods and people moving.

The chapters on landscape, hydrology, and transport in the first part of this thesis have reconstructed the topography and infrastructure of the Roman transport network in Northern Italy. This reconstruction will form the basis of the network model analysed in the following chapter, which will be used to answer questions about the cost and speed of transport across the region during the Roman era.

Chapter 4

Modelling the Transport Network

Located far inland, the western reaches of the Po valley were hundreds of kilometres from the nearest seaport. A robust and extensive transport network was necessary to convey imported goods from the coast inland and transport local exports in the opposite direction. The previous chapter demonstrated that substantial capital and effort was spent on improving transport links across Northern Italy. The physical remains of stone and concrete port infrastructure at sites such as Aquileia, Ivrea, and Tortona, and the monumental cuttings, bridges, and viaducts of the Aosta valley, all attest to the effort involved in reducing the time and cost of moving goods and people from one place to another. Building on the previous analysis of the natural landscape and transport infrastructure, this chapter examines the extent to which the impact of the transport network in facilitating trade can be mapped and quantified.

Over the past two decades, network modelling has seen increased application to the study of ancient transport systems.¹ Many of these studies have used network modelling to measure connectivity and accessibility across and between regions (see below), which can be defined as ‘the relationship between places in terms of the costs and time required to move between them, rather than their geographical distance’.² Theoretically, the lower the cost in time and money to reach one place from another, the greater the level of that region’s connectivity, and the greater the scope for goods and people to access it from further afield.³ Archaeological and geomorphological investigation has helped to reconstruct the landscape and physical routes of the ancient transport networks used in these models, while extant literary and epigraphic evidence, in particular Diocletian’s

¹ Brughmans (2010); (2013); Knappett (2013). See Collar et al. (2015) for an overview of the adoption of network analysis amongst the archaeological community, and Brughmans (2022) for a discussion of the importance of applying formal modelling to the study of the Roman Economy more generally.

² Cioffi (2016), 2.

³ Brughmans (2013); Horden and Purcell (2000), Chapter 5.

Edict on Maximum Prices, can be used to give estimates of the time and cost of different transport modes.

Roman Italy's transport network has not been extensively explored via network modelling, with only two major published studies applying this methodology to the region.⁴ Carreras and De Soto's analysis attempted to map the accessibility and connectivity of the Italian Peninsula during the Roman period; however, their model is somewhat less developed than their prior work on the Iberian Peninsula and Britain (see Figure 4.1).⁵ It assumes the Po to be the only navigable river in the region and terminates its navigability at Piacenza. It also excludes many of the regions minor roads and the para-littoral canal system. The Stanford ORBIS network model has been used to map cost and connectivity across the Roman Empire (see Figure 4.2), but its coverage of Northern Italy is also lacking.⁶ Several major roads are missing and the Po river network is completely absent from the model. Northern Italy's transport network, as demonstrated in the preceding two chapters, is more extensive and complex. Both Carrero and De Soto's model and ORBIS suggest that Northern Italy was isolated (and the Po valley in particular) from the rest of the Italian peninsula and Rome, something that has also been commented on by modern historians (See Section 1.2). Yet how poorly connected was the interior of Northern Italy in actuality? Creating a dedicated network model provides a way to test these assumptions by mapping the cost and time of reaching inland areas from the coast and vice versa.

This chapter analyses two network models simulating the cost and time of regular and heavy cargoes being transport across Northern Italy, against which the distribution of material evidence from the region (examined in the latter half of this thesis) can be compared. The past use of network analysis in archaeology is examined, alongside some of its limitations. A methodology for the analysis is given, detailing the software and variables used. This is followed by a presentation of the models' results. The models answer several questions related to the transport network of Northern Italy, exploring which were the most cost-effective and time-effective routes for imports arriving from the Adriatic and Ligurian coasts. They identify which areas of the valley were the most accessible from the Adriatic and Ligurian coasts, alongside which ports were the most accessible

⁴ Carreras and De Soto (2013); Scheidel (2014).

⁵ Carreras and De Soto (2013). The model excludes parts of Northern Italy, Southern Puglia, and Southern Sicily. There are also spikes in connectivity, such as the one between Piacenza and the Ligurian coast, which do not match patterns suggested by the historical and archaeological record. See Carreras and De Soto (2010); De Soto (2019); De Soto and Carreras (2014), for their work on Britain and the Iberian Peninsula. Flückiger et al.'s (2021) paper on transport connectivity in the Western Empire (which includes the Italian peninsula) suffers many of the same pitfalls.

⁶ Meeks (2015); Scheidel (2014).

from sites in the upper and middle valley. Finally, the chapter examines how the network of rivers, roads, and canals facilitated the spread of goods into otherwise inaccessible areas. The locations of sites mentioned within this chapter can be viewed in Figure 4.3.

4.1 Networks

A network model in its most basic form is a graph comprised of nodes (points) and edges (lines). Each node forms a junction in the network and the edges form the links between them. Network modelling has seen utilisation amongst a wide range of disciplines and is rooted in graph theory, a field of mathematics where interactions are explored through the pairwise relationship between nodes and edges.⁷ Network graphs can be used to model a range of relationships and can be both undirected and directed. In an undirected graph, the edges link each node symmetrically, while in a directed graph, these links may be asymmetrical, giving the potential for both nodes and edges to have a unique weight in the network.⁸ Network graphs can be created in both abstract and spatial dimensions. Abstract networks might graph relationships that do not exist in physical space. They have seen widespread application amongst the social sciences through the use of Social Network Analysis (SNA), where graphs have been used to map connections amongst sets of social actors, such as the spread of messages and ideas.⁹ Alternatively, Spatial Network Analysis (SpNA) maps physical relationships, where the nodes and edges represent features that exist in real space. The rise of spatial network modelling has been driven, in part, by the study of transport networks by urban planners, where network modelling has been used to assist with mapping traffic flow, connectivity, and accessibility.¹⁰

4.1.1 Networks in Roman Archaeology

In archaeology, network graphs have been used to map past exchanges, interactions, and identities.¹¹ First applied in the 1960s, network modelling has grown in popularity over the last decade, as the theory and software needed has become

⁷ Brughmans (2013), 624-628. Graph theory has its origins in the eighteenth century, when Leonhard Euler created a methodology using nodes and edges to solve the ‘Bridges of Konigsberg’ mathematical problem.

⁸ There are also multi-directed graphs, where two nodes may be joined by multiple, as opposed to a single edge.

⁹ Knoke and Yang (2008); Scott (2017); Shafie et al. (2020).

¹⁰ Andris and O’Sullivan (2021); Blanchard and Volchenkov (2009); Okabe and Sugihara (2012).

¹¹ Collar et al. (2015); Knappett (2013); Mills (2017).

increasingly accessible.¹² In particular, the ability of network analysis to handle and visualise large, complex datasets, alongside its compatibility and ability to complement other, more established tools such as GIS, has helped drive its adoption within the archaeological community.¹³

Both SNA and SpNA have been applied to the study of the Roman world by archaeologists. SNA has been used to examine relationships based on material culture between sites, and the strength of interaction between them.¹⁴ These mainly take the form of abstract networks, among the most influential being that of Brughmans and Poblome, which used agent-based modelling to graph the movement of Eastern Terra Sigillata based on the theories of economic integration proposed by Peter Bang and Peter Temin.¹⁵ Others include Livarda and Orengo's studies on the distribution of 'exotic' imports into Roman Britain, Graham and Weingart's model of the Roman brick trade, Flückiger et al.'s examination of transport and economic integration in the Western Empire, and Collar's mapping of religious networks across the Roman World.¹⁶

While the examination of abstract networks using SNA has helped open new avenues of research, the study of ancient transport (using an SpNA toolset) remains one of the most prominent areas of Roman archaeology in which network models have been applied.¹⁷ Transport systems exist as spatial networks in real space and are easily translated into network graphs, where each edge represents a section of the route (such as a road, river, or sea-lane) and each node a junction between them.¹⁸ Network modelling has been applied to the study of Roman transport at a variety of levels, ranging from the entirety of the Roman Empire (as is the case of the Stanford ORBIS model), an individual province (such as De Soto's work on Hispania Tarraconensis), to that of a single city (demonstrated by Livarda and Orengo's analysis of Roman London).¹⁹ Modelling has also been used to identify the configuration of transport networks, highlighting important routes and junctions within the network alongside mapping areas of high and low

¹² Collar et al. (2015).

¹³ Mills (2017), 381.

¹⁴ Brughmans (2013); Sindbæk (2013).

¹⁵ Brughmans (2020); Brughmans and Poblome (2016a); (2016b).

¹⁶ Collar (2013); Flückiger et al. (2021); Graham and Weingart (2015); Livarda and Orengo (2015); Orengo and Livarda (2016).

¹⁷ See, Brughmans (2013); Carreras and De Soto (2010); (2013); De Soto (2019); Graham (2006); Isaksen (2008); Orengo and Livarda (2016); Preiser-Kapeller and Werther (2018); Scheidel (2014).

¹⁸ Studies have also attempted to map transport in both spatial and conceptual networks. For example, Graham's (2006) network of the *Antonine Itineraries* sought to demonstrate the conceptual experience of a traveller using the Itineraries as a guide and explore how Roman communication routes developed.

¹⁹ Bongers (2020); De Soto (2010); De Soto and Carreras (2014); Livarda and Orengo (2015); Meeks (2015); Scheidel (2014).

connectivity.²⁰

4.1.2 Network Limitations

The sophistication of network modelling has grown over the past decade, as both the software available and thinking on Roman transport has developed. Multiple variables, such as cost, time, and seasonality, can be factored into models, and a plethora of network metrics, such as betweenness and closeness centrality, can be measured. However, the application of networks to the study of the ancient world has not been without criticism.²¹

First and foremost, the incompleteness of the archaeological record means datasets will inevitably be fragmentary, and it is rare that a complete network survives. This can be further compounded by the disparate publication and accessibility of information. Educated guesswork is often required to fill these gaps, the quality of which can vary. For example, Least Cost Pathways analysis has been used to indicate the likely route of missing roads in some transport models.²² Alternatively, ancient literature has been used to indicate absent links along proposed routes, with locations in the *Antonine Itineraries* providing missing network nodes.²³ Even so, it is unlikely that a network graph will ever represent a flawless recreation of the ancient world.

Second, the factors and variables used to weight networks (discussed in further detail below), need to be clearly defined. These should be based on the historical record, although this is not always the case.²⁴ The number of factors and variables should also be carefully considered. There should be enough variables in the model to give a realistic approximation of ancient conditions, however, the more variables that are added to a model, the more complex it becomes. There is a risk that the underlying research questions can become swamped by an excess of factors, and a balance must be struck between striving for maximum accuracy and the legibility of the model.

Finally, scale can pose a problem, with network resolution an important factor to consider during the formulation of research questions. The largest network model of Roman transport is ORBIS, which sought to analyse the cost of transport between different locations across the Roman Empire, taking into account

²⁰ Bell et al. (2002); Bongers (2020); Carreras and De Soto (2013); De Soto (2019); Orengo and Livarda (2016).

²¹ See van Oyen's (2017) response to Brughmans and Poblome (2016a), alongside Brughmans and Poblome's (2017) reply, with Knappett (2013), 7-10; Tartaron (2014), 60-61.

²² See Güimil-Fariña and Parcero-Oubiña (2015); Orengo and Livarda (2016).

²³ Isaksen (2008).

²⁴ For example, the origin of figures for transshipment time used in Orengo and Livarda (2016) are not explained.

cost, time, and seasonality. Yet, with a model the size of ORBIS, some details were inevitably sacrificed to make the network manageable and (perhaps most importantly) interpretable (see Figure 4.4).²⁵ Smaller regional studies allow for the creation of more detailed networks which may more accurately reflect ancient reality, but there remains a danger of too much detail. Modelling every minor road, river, and junction risks swamping the viewer with information, obscuring overarching trends. The inclusion of such micro-details, even at a regional level, can significantly increase the time and computing power needed to run a model, reducing the number of analyses that can be run and making replicability difficult for those without the necessary hardware. Also linked to scale is the issue of defining the limits of a network model, with the spatial boundaries of some prior networks having been a cause of past criticism.²⁶ The use of arbitrary boundaries (for example, the borders of modern administrative districts or countries), fail to take into account natural barriers and corridors that may prove a more accurate regional limit. While there was no such thing as a closed transport system in the ancient world, realistic boundaries for a study should be selected.

While all the above are valid criticisms of network modelling, this is not to say models lack a place in the study of the past. Models, by their very nature, are heuristic devices, tools to explore how transport networks may have operated rather than an exact representation of the ancient world. So long as potential flaws and limitations within the models are acknowledged and engaged with, they can still form valuable instruments for investigating wider research questions. With this in mind, the factors and variables used in the subsequent network analysis are outlined and discussed below.

4.2 Factors and Variables

One of the most important considerations in any network model are what measurements to use as weights for the nodes and edges of the graph. These measurements are responsible for supplying the cost (be it in money, time, or some other variable) to move along network edges and through its nodes, making the model more than just a series of dots and lines. As connectivity is defined as the relationship between places through monetary cost and time, rather than geographic distance, both these variables will be used as network weights in the subsequent analysis.²⁷ Although data from the ancient world for the monetary

²⁵ ORBIS utilised 750 prominent sites or junctions across the empire as nodes for its model, a fraction of its total settlements (Scheidel (2014), 8).

²⁶ Blake (2014); Knappett (2013); Smith (2003); (2007); Terrell (2013).

²⁷ Horden and Purcell (2000), Chapter 5.

Transport Type	DeLaine 1992	De Soto 2019
Maritime	6.4 kmph	4.62 kmph
Fluvial (Downstream)	n/a	2.51 kmph
Fluvial (Upstream)	n/a	0.62 kmph
Overland	1.6 kmph	2.5 kmph

Table 4.1: Comparative estimates for the speed of transport in the Roman world.

costs and speed of ancient transport survives in fragmented form, they are not without their limitations.

Time has proved a popular network weight, reflecting the speeds at which different forms of transport moved (see Table 4.1).²⁸ Avoiding the more problematic data for monetary costs (see below) and drawing more readily on comparative data from later periods, models using time work on the assumption that the less time it took to reach an area, the more connected it was. While time would have been an important factor to consider for perishable goods, alongside the movement of people and information, it may have been a lesser concern for more durable cargoes such as stone or metal ingots. In this case, the monetary cost of transport may have been the most pressing factor. Indeed, DeLaine estimated that 50% of the construction costs for the Baths of Caracalla may have been consumed by transport.²⁹

The figures for transport cost in the ancient world have their basis in Diocletian’s Price Edict of AD 301 (see Table 4.2).³⁰ The Price Edict text gives the maximum price of transport across 51 maritime routes, with costs ranging between 4 and 26 *denarii* for the transport of a single *kastrensis modius* (approx-

²⁸ For example, De Soto (2019); Orenge and Livarda (2016); Scheidel (2014).

²⁹ DeLaine (1997), 216–17.

³⁰ DeLaine gives the cost of transport in *kastrensis modius* (KM) to transport one tonne of cargo (T) over a Roman mile (RM). Here, a *kastrensis modius* is taken to be the equivalent of 100 Diocletianic *denarii*. These figures were compiled by DeLaine as part of her doctoral thesis and refined in its subsequent publication (DeLaine (1992), 123-126; (1997), 207-20). For ORBIS, the cost of maritime transport is expressed as *denarii* to transport 1 kilogram of wheat per day of sailing (<https://orbis.stanford.edu/> Building ORBIS. Historical Evidence. Accessed 24/03/2021). For fluvial and overland routes, the cost of transport is expressed as *denarii* to transport 1 kilogram of wheat per kilometre (<https://orbis.stanford.edu/> Building ORBIS. Historical Evidence. Accessed 24/03/2021). For De Soto’s model, the cost of transport is expressed in kilograms of wheat to transport one tonne of cargo over a kilometre. Here, a kilogram of wheat is the equivalent of 10 Diocletianic *denarii*. The figures were initially calculated by Carreras (Carreras (1994a) 338-40; Carreras (1994b) 28-33), who took the cost of journeys in the Price Edict and divided them by the distance they covered. The correlation between distance and cost was checked by regression analysis, which returned a 90% match. From these figures, an average cost in kilograms of wheat to transport a tonne of wheat per kilometre was generated, with the cost ratios between transport types closely matching other previous estimates (see Table 4.3). De Soto would go on to refine these figures in his own thesis and subsequent work (De Soto (2010); (2019)).

Transport Type	DeLaine 1992	ORBIS 2014	De Soto 2019
Maritime	0.0048 KM/t/RM	0.1 <i>denarii</i> /1 kg wheat/day	0.097 kg wheat/t/km
Fluvial (Downstream)	0.023 KM/t/RM	0.0034 <i>denarii</i> /1 kg wheat/km	0.33 kg wheat/t/km
Fluvial (Upstream)	0.046 KM/t/RM	0.0068 <i>denarii</i> /1 kg wheat/km	0.66 kg wheat/t/km
Overland	0.2 KM/t/RM	0.035 <i>denarii</i> /1 kg wheat/km	4.92 kg wheat/t/km

Table 4.2: Comparative estimates for the monetary cost of transport in the Roman world (kg = kilogram, km = kilometres, KM = *kastrensis modii*, RM = Roman miles, t = tonne).

imately 12.9 litres of wheat).³¹ For fluvial transport, only the Aphrodisias copy of the Price Edict distinguishes between upstream and downstream carriage. The Edict gives a price of 1 *denarius* per *kastrensis modius* per 20 Roman miles of downstream travel and 2 *denarii* per *kastrensis modius* per 20 Roman miles of upstream travel.³² For terrestrial transport, the Edict gives the maximum prices of 2 *denarii* per Roman mile for a passenger in a carriage, 4 *denarii* for a fully laden donkey per Roman mile, 8 *denarii* for a camel carrying 600 Roman pounds per Roman mile, and 20 *denarii* for a wagon carrying 1,200 Roman pounds per Roman mile.³³ As the value of the *denarius* was not consistent throughout Roman history (seeing significant devaluation from the first century AD onwards), some scholars have instead sought to express the freight rates contained within the Price Edict in the form of a wheat equivalent (see Table 4.2). As the value of wheat is thought to have remained relatively stable throughout the Roman period (with demand and consumption remaining constant), expressing transport costs as a unit of wheat allows them to be used for transport in earlier periods when the *denarius* had greater value.³⁴

The figures presented in the Price Edict have allowed the extrapolation of different ratios of cost between overland, upstream, downstream, and maritime transport, and from them, a base cost per mile/kilometre (see Table 4.3). However, the Edict is a problematic piece of evidence, and it has been extensively critiqued as a source of pricing in the Roman era.³⁵ It survives in a fragmen-

³¹ It is worth noting that the monetary costs for maritime transport given in the Price Edict are probably based on time, rather than distance (Arnaud (2007); Scheidel (2013)).

³² *Edict of Maximum Prices*, XXXVA.31-33.

³³ *Edict of Maximum Prices*, XVII.1-5.

³⁴ The *kastrensis modius* is assumed to reflect weight, rather than volume, in these figures. See Corbier (1985); DeLaine (1992), 22-23; Duncan-Jones (1978) for further discussion on the use of wheat equivalences and the stability of the price and demand for wheat during the Roman period.

³⁵ For example, Corcoran and DeLaine (1994) have highlighted problematic assumptions made

Transport Type	Price Edict, AD 301 (Erim and Reynolds 1970)	Scheidel 2014	De Soto 2019
Maritime	1	1	1
Fluvial (Downstream)	3.9	5	3.4
Fluvial (Upstream)	7.7	10	6.8
Overland	42	52	50.72

Table 4.3: Comparative ratios for the monetary cost of transport in the Roman world.

Source	Sea:Land	Sea:River	River:Land
Price Edict, AD 301 (Erim and Reynolds 1970)	1:42	1:3.9 (downstream) 1:7.7 (upstream)	1:10.8 (downstream) 1:5.5 (upstream)
Thirteenth-century Norwich (Salzman 1967, 119)	1:34	1:2	1:16.8
Sixteenth-century Cambridge (Alexander 1995, 127)	\	\	1:8
Sixteenth-century Sens (Cailleauxn 1999, 195)	\	\	1:12.5
Eighteenth-century England (Duncan-Jones 1982, 368)	1:22.6	1:4.7	1:4.8

Table 4.4: Comparative ratios for the monetary cost of transport across history. (After Russell (2013), 96).

tary state, and only records maximum prices relevant to the early fourth century AD. There was probably significant variation in costs below this total, and prices may have been higher or lower in the preceding and following periods. Furthermore, the decree seems to have been principally enacted in the eastern half of the empire, giving the potential for regional price variation. These concerns aside, Russell has shown that the ratios extrapolated from transport costs given by the Price Edict (see Table 4.3) are not dissimilar to cost ratios between land, river, and sea transportation from other periods (see Table 4.4).³⁶

The ratios outlined above have led to an accepted hierarchy amongst scholars in the cost and speed of transport (although as the above tables demonstrate, there is considerable variation amongst the competing values). Maritime transport is viewed as the cheapest and quickest, followed by fluvial transport. Upstream travel is viewed as both more expensive and slower than downstream due to the need to add a means of propulsion (often hauliers or rowers) to counteract the strength of the current (see Section 3.1.3). Overland transport is considered the most expensive, although potentially faster than upstream haulage. Of

between measurements of products and their prices in the Edict, while Duncan-Jones (1982) noted that the Edict largely underestimates the cost of passenger travel in comparison to cargo.

³⁶ Russell (2013), 96.

course, the variables outlined above and used in the network model can only ever be estimates of time and cost. No model could hope to perfectly reflect the thousand and one factors that governed transport in the Roman world. Shippers and hauliers would have competed amongst themselves over prices (which likely differed between regions), while weather conditions, the fitness of hauliers/rowers, the quality of the vehicle/vessel, and the fragility of the cargo would all have impacted the speed at which transport moved. Likewise, the speed estimates for transport relate to the movement of cargo. Riders on horseback or those using the fast rowing service may have travelled substantially quicker than the speeds suggested above.

Another significant variation that transport comparisons often fail to consider is the difference in the volume of cargo each transport type could carry.³⁷ The average ancient wagon was unlikely to have been able to carry more than between 0.5-2 t, although specialist, reinforced vehicles, such as those used for the transport of stone, would have been able to support more.³⁸ In contrast, the Zwammerdam 4 barge is thought to have had a cargo capacity of c.100 t, while the fluvio-maritime Comacchio vessel had a capacity of c.130 t.³⁹ Swapping from one transport type to another with a lower capacity meant additional handling of the cargo, greater complexity in the supply chain, and more risk of breakages or losses. Moving cargo from a low-capacity transport to a high-capacity transport also possessed its own risks and difficulties. Transports with a high cargo capacity would need to wait until they were fully loaded before moving, potentially increasing the time and cost of transshipment. The impact of the loss of a single high-capacity transport (such as a river barge), would also have been much greater than that of a single low-capacity transport (such as a wagon). The simplification necessitated by network modelling means it is difficult to quantify the impact of variables like capacity on cost and time, but the advantages suggested by certain types of transport over another may not be as straightforward as they first appear.

4.3 Missing Variables

While cost and time form the main figures used in the weighting of the network model, there are several important elements of transportation in Northern Italy for which cost and time estimates are missing in the historical record. These,

³⁷ Adams (2012), 220-21.

³⁸ Russell (2013), 98. DeLaine (1992), 121, compiles several sets of ancient figures, which give values of between 400 kg and 640 kg per yoke for maximum load.

³⁹ Bockius (2004), 482; Bondesan et al. (1990), 13.

alongside some potential solutions, are discussed below.

4.3.1 Canals

The para-littoral canal system formed a key part of Northern Italy's transport network, running over 120 Roman miles between Ravenna and Altinum and potentially as far as Aquileia (see Section 3.1.2). The canals offered an alternative, and potentially safer, route between these two ports and circumvented the need to navigate the dangerous mouths of the Po to access the river network. The expense and time involved in the creation of canals means the decisions to construct them were not taken lightly, yet few network models take canals into account. This may, in part, be due to the fact that transport canals were not widespread across the Roman Empire, documented in only a handful of locations (mostly in the north-west) and, even then, running over short distances.⁴⁰ The other reason comes from a lack of known figures for the cost (in both time and money) of canal transport in the ancient world. Some possible ancient evidence for the cost of canal transport comes from the Aphrodisias copy of the Price Edict, which gives a cost of 7,500 *denarii* to ship 1,000 *kastrenses modii* from Ravenna to Aquileia during the fourth century AD.⁴¹ This may have utilised the para-littoral canal system, assuming it was extended to Aquileia.⁴² However, over the roughly 300 km journey between the two ports, this price equates to 0.0025 *denarii* per kilogram of wheat per kilometre, significantly cheaper than the 0.0034 *denarii* per kilogram per kilometre for the cost of downstream fluvial transport given by the Edict.⁴³ For reasons discussed below, this figure seems unlikely to be an accurate reflection of the cost of canal transport. From Roman Egypt, a papyrus records the cost of transport between Arsinoe and Ptolemais Hormou by canal as being 6.3% of the cargo's value, but it is uncertain how applicable this figure is to wider contexts.⁴⁴

Canals probably lay somewhere between downstream and upstream fluvial transport in terms of cost. Although the slack water of the canals would have lacked a current, removing the need to expend energy overcoming it, this also meant a method of propulsion was needed to move the vessel. If hauliers were used, they would have required the presence of a towpath. Excavation in Ravenna suggests that a road ran parallel to the *Fossa Augusta* as it left the city heading north, although it is uncertain how far this extended (see Section 3.1.2). It

⁴⁰ Grewe (2009); Salomon et al. (2014).

⁴¹ *Edict of Maximum Prices*, XXXVA.33.

⁴² Laurence (1999), 118; Uggeri (1987), 343; (1997), 60.

⁴³ It is possible that the price for this route was discounted in some way (<https://orbis.stanford.edu/> Building ORBIS. Historical Evidence. Accessed 24/03/2021).

⁴⁴ Adams (2012), 222; (2018), 178-97; BGU III. 802.

is worth repeating, however, that large sections, the para-littoral canal system did not comprise of canals in the traditional sense. Wherever they could, the system utilised the ancient lagoons, where vessels would have needed to cross large stretches of open water. This would have necessitated a slower pace than those recorded for human or horse-drawn barges (see below) and would also have required an alternative mode of propulsion to haulage by man or beast, such as oars or sail.

Comparative figures from the eighteenth and nineteenth centuries provide a further indication for the cost and speed of canal transport. Hadfield gives a speed of between 3.21 and 6.4 kmph for a fully laden canal barge being towed by horse, assuming the presence of a towpath.⁴⁵ The journey time between Manchester and Sheffield via canal (a distance of some 160 km), in the 1830s, was given as taking 8 days.⁴⁶ The vessel would have needed to cover 20 km per day, and, assuming it travelled between 09:00-17:00, its average speed would be 2.5 km per hour. This is somewhat slower than Hadfield's figures but can be explained by the need to stop while traversing locks, a problem not faced by the Romans.⁴⁷ In terms of monetary cost, there are several comparisons between the price of canal and overland transport from the eighteenth and nineteenth centuries. Thompson gives the cost of several journeys by canal and road between Manchester, Worsley, and Nottingham, with the average ratio between the two being 1:3.⁴⁸ Alternatively, a ratio of 1:6.6, is given for the cost of canal vs. road transport between Manchester and Liverpool.⁴⁹ Using the figures for Roman transport costs given by De Soto, these ratios can be converted into prices. De Soto gives a cost of 4.92 kg wheat/T/km for overland transport. If the cost of canal transport was a third of that, as suggested by the ratio of 1:3, then the cost of canal transport would be 1.64 kg wheat/T/km. However, when compared to other transport costs from the Roman period, this seems somewhat expensive, well over double the cost of upstream fluvial travel (see Table 4.2). If the ratio of 1:6.6 is used, the resultant price is 0.74 kg/T/km, a number closer to that of upstream fluvial transport. However, even this number may be too much. Given that the canals

⁴⁵ Hadfield (1959), 58, 173. A similar figure is given by Thompson (1904), 47. Speeds of up to 19.3 kmph were possible with the use of specially constructed boats. The inclusion of additional horses could also increase the speed of the barge or weight of the cargo it carried without impacting its velocity.

⁴⁶ Porteous (1977), 157.

⁴⁷ The pound lock is thought to have been invented in the fourteenth century AD (Campbell (2012), 224, n. 140).

⁴⁸ Thompson (1904), 8. A journey from Manchester to Worsley was costed at 8/- per tonne overland, and 2/6 by canal, while a journey from Manchester to Nottingham was costed at £6 per tonne for overland and £2 for canal.

⁴⁹ Thompson (1904), 8. A cost of 40/- per tonne is given for overland, while the equivalent journey by canal was 6/-.

were able to access the Adriatic Lagoon System, it is probable that the vessels using them were able to utilise sails to propel themselves, moving in a similar way to maritime transport and possibly reducing cost. If a barge was not equipped with sails or was not able to use them, then an alternate means of propulsion, such as oars, potentially increasing cost, yet there is no reason as to why this would be more expensive than upstream river travel.

Canals presented a way to transport goods and people without many of the risks associated with fluvial or maritime transportation. Although canals mainly contained still water, traversing them shared several similarities with upstream fluvial transport, namely the need for a method of propulsion. While this would have added cost, comparative evidence has shown that considerable speeds could be achieved by hauling a barge over still water, faster than downstream fluvial travel. For the network model presented here, a speed of 3.21 kmph is used, taken from the eighteenth-century data supplied by Hadfield and Thompson. This would still place canals as the second fastest mode of transport after maritime. For monetary cost, both prices suggested by the comparative data seemed too high when compared with those from the Roman era. As paying for a method of propulsion likely formed the main expense for canal transport, a price of 0.66 kg/T/km is used, the same as upstream fluvial transport.

4.3.2 Transshipment

One of the most important stages in a cargo's journey is transshipment, where goods are transferred from one form of transport to another. Transshipment could take a variety of forms. Not all settlements had access to a navigable river or seaport, necessitating the transfer of cargo to terrestrial transport to complete its journey. Cargoes might also be split up into smaller consignments or united into bigger shipments, while still utilising the same form of transport. Unfortunately, transshipment costs are absent from the Price Edict, and due to a lack of alternative ancient evidence, are generally absent from many network models of Roman transport.⁵⁰ Yet transshipment could be an expensive and time-consuming process. Indeed, for heavy and bulky cargoes, transshipment could make up between 20-30% of the total cost of transport, making its inclusion in the analysis

⁵⁰ The original ORBIS model did not include transfer costs, although an upgrade allowed users to manually add a time cost in the form of days (<http://orbis.stanford.edu/#seaexpense> Accessed 14/09/20). Orengo and Livarda's model includes estimates of the time it would take to move from one transport type to another. They suggested: Road-River, 360 mins; Sea-River, 600 mins; Sea-Road, 360 mins, but do not explain how they reached these figures (Orengo and Livarda (2016), 23).

essential.⁵¹

Transshipment costs are likely to have varied extensively in terms of both time and expense, dependent on both the cargo type and the facilities of the port where transshipment occurred. Cranes and winches would have been essential for heavy cargoes such as stone, while cargoes of smaller goods, such as amphorae and finewares, could have been loaded by hand.⁵² While there are no surviving ancient estimates for the cost of transshipment, several fragments of Egyptian papyri give an indication of time. One, a shipping contract from the Fayum dated to the third century AD, records two days for the loading of a cargo of 250 *artabas* (approximately 9.5 t) of *lachanospermon* (vegetable seed), with four days for its unloading.⁵³ Another papyrus from Oxyrhynchus dated to the second century AD records the delivery and loading over eight days of 10,000 *artabas* onto several river vessels.⁵⁴ The total amount loaded each day varied between 424 *artabas* and 1324 *artabas*, but it is unknown how many workers were involved, how these amounts were distributed, or between how many river vessels.⁵⁵ Regardless, it suggests that the ability to load cargoes weighing in the tens of tonnes over a 24-hour period existed during the Roman era.

Comparative sources from later periods also suggest there was considerable variation in the time it took to load and unload cargo, the size of the cargo being one of the most important factors. For example, eighteenth-century harbour records from Marseille indicate that a 200 t cargo of salted cod took a week to unload, while records from the harbour of Charleston, South Carolina, suggest it could take between two and four weeks (excluding Sundays) to load a cargo of 400 t.⁵⁶ However, the timings for transshipment given above are for cargoes in the hundreds of tonnes for large ocean-going vessels of the eighteenth century. Roman maritime ships may have had similar capacity to this, but river barges were substantially smaller than seafaring vessels, generally less than 100 t (see Section 3.1.4).

Nineteenth-century building manuals, such as Pegoretti's *Manuale pratico*, have proved another useful source of data concerning labour and man hours.⁵⁷

⁵¹ Russell (2013), 137. These figures are based on cathedral building accounts from the thirteenth and sixteenth centuries.

⁵² The majority of vessels would have been loaded and unloaded by hand, a practice that endured into the twentieth century (it is estimated that 95% of loading and unloading was still being carried out by hand in the Port of Manchester at the start of the twentieth century, Simey (1954), 30-31). Surviving epigraphy from Portus and Ostia suggests a wide variety of specialisations amongst cargo porters (Rickman (1971), 263).

⁵³ Adams (2018), 192. *P. Lond.* III. 948 p. 219 (AD 236) = M. Chr. 341.

⁵⁴ *P. Oxy.* XXXIII. 2670 (AD 127).

⁵⁵ Adams (2018), 187.

⁵⁶ Thompson (2015), 21-23.

⁵⁷ Pegoretti (1869).

Task	Lower time (minutes)	Upper time (minutes)
Loading 1 cubic metre of porphyry, granite, serpentine, or other similar durable stone and marble.	30	60
Loading 1 cubic metre of limestone, travertine, sandstone, or puddingstone.	24	48
Loading 1 cubic metre of tufa, soft limestone, chalkstone, pumice, or volcanic slag.	15	30

Table 4.5: The time in minutes to transfer different types of stone from a boat or cart (Adapted from Pegoretti (1869), 291).

Given the many similarities between construction in the early modern and ancient world, they have been used as a source of comparison for labour figures in the Roman period.⁵⁸ While the manuals are principally focused on activities related to construction, Pegoretti includes various labour constants (measured in man-hours) for the loading of blocks of stone and marble on wagons and boats (see Table 4.5).⁵⁹ From these figures, it is evident that a large cargo of heavy stone may have taken several days to safely unload and transfer.⁶⁰ However, cargoes of lighter stone, such as soft limestone or pumice, might have been unloaded in half the time, demonstrating the variation present when it comes to transshipment times. Furthermore, while these figures cover the transshipment of stone, a heavy, bulky, and subsequently time-consuming item to load and unload, cargoes of amphora and finewares that could be loaded and unloaded without the need for cranes and other specialised equipment, would probably have been significantly faster to tranship.

In terms of the cost of transshipment, there is even less evidence. If we return to the third-century AD shipping contract from the Fayum discussed above, Adams estimates that the shipper's payment to transport the cargo was equivalent to 2% of its value, but it is uncertain whether this covered the loading and unloading of the cargo, or if this was an additional cost at either end of the journey.⁶¹ From the medieval period, cathedral accounts from Norwich record that transshipment of stone from seagoing vessels to riverine barges at Great Yarmouth was equiv-

⁵⁸ For example, Barresi (2003); Carè (2005); DeLaine (2015); Russell (2013). The labour estimates given by the manuals have proved relatively accurate when compared to the labour exerted by modern stonemasons (Barker and Russell (2012)).

⁵⁹ Pegoretti (1869), 281.

⁶⁰ The figures assume that a cartier or shipman is being assisted by a stonecutter and one or two handlers for each cubic metre of stone unloaded. Larger blocks of stone or architectural elements, would have likely required additional hands to aid in their transfer, potentially increasing cost.

⁶¹ Adams (2018), 192. *P. Lond.* III. 948 p. 219 (AD 236) = M. Chr. 341.

alent to 20% of the cost of transporting the stone upstream to Norwich.⁶² This was a journey of some 46 km. If De Soto's figures for transport cost are used, this upstream journey would have cost 30.36 kg wheat, 20% of which returns a transshipment cost of 6.072 kg wheat. However, the figure of 20% suggested by the Norwich Cathedral accounts is a variable one that ultimately depended on journey length. Furthermore, as with Pegoretti's figures above, this number relates to the transshipment of stone, rather than amphora and finewares. These lighter cargoes would likely have been significantly cheaper to tranship.

Given the many variables involved, the cost and time of transshipment is unique for each journey and cargo. Unfortunately, the mechanics of the network analysis require a single, uniform value to be placed across the model, necessitating the use of broadly indicative figures to represent this complex process.⁶³ Since the evidence for Egypt suggests it was possible to load cargoes in the tens of tonnes over the period of a single day, a transshipment time of 12 hours was selected.⁶⁴ This covers the average hours of daylight over the course of a day in Italy.⁶⁵ In terms of monetary cost, the lack of ancient data significantly hampers attempts to gain an accurate estimate of what transshipment may have cost. The third-century AD shipping contract from Oxyrhynchus, which gives a figure of 2% of the value of the cargo as payment for its transport, serves as the only piece of ancient evidence to come close to engaging with the cost of transshipment. While it is uncertain what services were covered by this figure, it forms a base to work from in the absence of other evidence. As the model maps the journey of a single tonne of cargo (theoretically 1000 kg wheat), then 2% of the value would be 20 kg wheat. This would thus give a transshipment cost of 20 kg wheat per tonne of cargo. However, as this price included the loading and unloading of the cargo at its origin and destination, this would need to be halved to 10 kg wheat per tonne of cargo.

While the values selected above serve as a broad estimate of transshipment costs, they are probably only reflective for the transshipment of lighter cargoes (such as amphora and finewares). Consequently, a second model has been created to reflect the transshipment of heavy cargoes that were more expensive and time consuming to move. In the second model, the time of transshipment has been

⁶² Russell (2013), 136-37.

⁶³ The transshipment figures presented cover the total cost and time of each transfer, not individual acts of loading and unloading at each new transfer. For example, the unloading of cargo from a barge and its subsequent loading onto a cart would be counted as a single transfer.

⁶⁴ Northern Italy has yet to return evidence of a fluvial vessel from the Roman period with a cargo capacity exceeding 20 tonnes (see Section 3.1.4).

⁶⁵ The average sunrise and sunset in Italy is 06:30 am and 18:40 pm respectively. The average hours of daylight are 12 hours and 10 minutes. The figure of 12 hours represents an absolute maximum working day. Most working days lasted 8 hours, between 09:00 and 17:00.

doubled to 24 hours to reflect the slower pace of loading and unloading. The cost for the transshipment of heavy goods is based on the figure of 20% of total cost suggested by the Norwich Cathedral accounts. This would give a figure of 200 kg wheat per tonne of cargo (halved to 100 kg wheat for each loading and unloading), one probably more reflective of the costs involved in the handling of heavy and bulky cargoes such as stone which would have required specialist equipment to transfer.

4.3.3 Gradient

Most network models use average measurements of monetary cost and time multiplied or divided by linear distance within their models to measure connectivity. However, neither of these methods truly takes into account the geographical complexities of the terrain transport networks covered. Networks have often struggled to reflect the spatial reality of the regions that they map. Topography significantly affected transport times and costs, and a rise in elevation, particularly the associated increase in gradient, could drastically increase the time and monetary cost of traversing the affected section of the network. The grade of a slope has a large impact on the efficiency and feasibility of its traversal. An incline of just 1% would have required double the number of haulage animals to move at the same speed as over level ground, and slopes of over 5% would likely have been impassable without specialist equipment for heavy loads.⁶⁶ The previous chapter highlighted some of the ways communities in Northern Italy sought to counteract or reduce the effects of slope on transport (see Section 3.2.2). Viaducts, cuttings, and switchback all helped to reduce the grade of a slope.

While the impact of gradient on the cost of transport is undeniable, applying this to network models has proved somewhat elusive. A possible solution would be to modify the cost and time values for each road segment relative to the gradient that segment covered. This would reflect the slower pace (and consequent expense) of travelling over steep terrain as opposed to the quicker (and cheaper) process of travelling over even ground. In order to do this, slope values (in percent) were generated for the region's roads, utilising z values taken from the model's digital elevation model (DEM). The DEM used in the model was the Copernicus EAA-10, a DEM created by the European Space Agency with a 10 m resolution.⁶⁷ This provided significant improvements to accuracy when compared with earlier 30 m and 90 m resolution DEMs available. Even with the high-resolution DEM, for some of the most mountainous areas (such as the Great

⁶⁶ Raepsaet (2009); Russell (2018a), 139.

⁶⁷ <https://spacedata.copernicus.eu/web/cscda/dataset-details?articleId=394198> (Accessed 29/08/2022).

Slope (percent)	Multiplier
0	1
1	1.01
2	1.04
3	1.09
4	1.16
5	1.25
6	1.36
7	1.49
8	1.64
9	1.81
10	2
11	2.21
12	2.44
13	2.69

Table 4.6: Multipliers for the cost of transport dependent on slope percentage.

St. Bernard Pass and the via Regina around Lake Como) the software struggled to calculate an accurate gradient. This necessitated the manual adjustment of some slope values to reflect the true gradient of the slope. These were taken from OpenStreetMap. The maximum recorded slope of the road network did not exceed 13%. Once slope values had been assigned to each section of the road network, the values for cost and time assigned for each segment were adjusted to take slope into account using the values in Table 4.6.⁶⁸ The multipliers here are based on the time taken to ascend or descend a slope. The greater the percent of the gradient, the greater the time taken to traverse it and the resulting costs due to delays. An alternative multiplier, proposed by Bell, Wilson, and Wickham, is based on the energy needed to traverse a slope.⁶⁹ The greater the energy required, the greater the cost and time taken to traverse the slope. When compared, the modifiers generated for time and energy do not differ significantly from each other (see Figure 4.5), so it was decided to use the modifiers for time, rather than energy. For the transport of heavy cargoes, these modifiers were tripled to take into account the added difficulties they faced.

⁶⁸ Values taken from ESRI exercise: Slopes, Sharp Turns, and Speed (https://www.esri.com/news/arcuser/0708/files/burnaby_1.pdf Accessed 03/10/20).

⁶⁹ Bell et al. (2002), 175. They use the equation $\tan(\text{slope})/\tan(1^\circ)$ to produce a figure for the increase in energy required.

4.4 Methodology

The following analysis is based on the methodology developed by De Soto in his 2010 thesis, with significant additions in the form of transshipment, slope, and canal costs.⁷⁰ The network presented here represents the peak extent of the transport network within Northern Italy during the Mid-Imperial period and tracks a hypothetical cargo of 1 tonne. The hypothetical cargo begins its journey on land. The model assumes that transport was taking place during the spring and summer months, a time of optimum weather and hydrological conditions on the region's rivers. It also assumes that transport travelled at a constant speed, as outlined below, and applies the maximum cost given by the Price Edict to transport. ArcGIS was chosen as the software to analyse the network, using the program's Network Analyst suite of tools. A full step-by-step methodology can be found in Appendix A, however, a brief overview of the creation of the network and the parameters used in the analysis is outlined below.

4.4.1 Digitising the Ancient Transport Network

The network model is comprised of a series of four vector datasets, containing the roads, navigable rivers, canals, and sea-lanes within the study area which provide the nodes and edges for the network analysis. The extent of the network can be seen in Figure 4.6. The Alps, Apennines, and the Adriatic and Ligurian Seas form natural limits to the study area, providing an enclosed space for the network analysis to run. Inevitably, there is a degree of simplification and assumption in the model, but the scale of the analysis should mean its results are broadly accurate.⁷¹

For the road network, a relatively complete map of the region's primary and secondary roads can be constructed from the archaeological record.⁷² The road vector dataset was originally imported from the Ancient World Mapping Centre's (AWMC) shapefile resource page.⁷³ Although the AWMC vector data offered a useful starting point, it needed significant alterations to be usable in the model. While the main pathways of the roads were broadly accurate, they did not take

⁷⁰ De Soto (2010). This methodology was refined in later works (De Soto (2019); De Soto and Carreras (2014)).

⁷¹ For example, bridges are assumed to have been present when crossing the region's rivers, and while the Po was likely only crossable by ferry (see Section 3.2.2), a distinction has not been made between ferries and bridges.

⁷² Here, a primary road is taken to mean a named consular road, while a secondary road refers to unnamed roads that were still of substantial construction and connected major settlements. The minor roads of the region, the *diverticuli* that connect villas and smaller settlements to the main network, were too numerous and poorly mapped to be included in the analysis.

⁷³ <http://awmc.unc.edu/wordpress/map-files/> (Accessed 13/10/20).

into account the topography of the region (some roads are mapped as traversing near-vertical surfaces in the Alps). Most of the AWMC vectors were redrawn in their entirety. This involved tracing the pathway of roads using satellite imagery, alongside georeferencing high resolution survey maps in GIS (such as the map series tracking the path of the via Postumia between Cremona in Cera (2000)) and tracing the outlined path. This resulted in far more accurate road vectors that followed realistic paths through the region's topography and matched the surviving archaeological evidence. This was especially true in the Alpine and Apennine areas of the model, where road gradient did not exceed 13 percent after the redrawing of the vectors. The AWMC dataset was then supplemented by other road data taken from regional publications, which was manually added to the shapefile via georeferencing.⁷⁴

The river network was created from the data for navigable rivers during the Roman period collected in Chapter 3 (see Section 3.1). The paths of the Po, Adige, and other rivers during the Roman period were taken from the AWMC river vector shapefile and corroborated with more recent geomorphological research.⁷⁵ Additional rivers not included in the AWMC vector file, such as the Stella, were manually added to the shapefile. Only rivers known to have been navigable were included, although it is likely there were significantly more navigable rivers within the region.

The canal network vectors were manually created. Given the limited archaeological evidence for the *Fossae Augusta*, *Claudia*, and *Flavia* (see Section 3.1.2), a degree of guesswork was necessary in constructing the vectors. Reconstructions of the path of the canals were taken from several sources and compared with the ancient topography.⁷⁶ From this, a possible route for the canals was created between Ravenna and Aquileia. Canal vectors were also placed in areas where ports (such as those at Milan, Tortona, and Vercelli) were connected to the river network by manmade channels. Finally, canal vectors were also used to model travel across the great pre-Alpine lakes of the region, as riverine craft using these lakes would have incurred similar challenges and costs to those of canals.

The maritime network vectors included in the model represent movement along the Adriatic and Ligurian coasts. A para-littoral route was selected, with connections to the region's major ports. Although fluvio-maritime vessels such as the Comacchio and Parco Teodorico wrecks had the ability to move interchangeably on inland and coastal waters (see Section 3.1.4), allowing near-seamless

⁷⁴ These included: Bosio (1991); Calzolari (1992); Labate (2019); Marini Calvini (1999); Ortalli (1992).

⁷⁵ See Bosio (1979); Calzolari (2007); Uggeri (1978); (2016).

⁷⁶ These included Manzelli (2000); Grazia Maioli (2018); Rousse (2013); Uggeri (1978); (1997).

movement between maritime, para-littoral canal, and fluvial contexts, it was decided to keep a firm separation between fluvial/canal and maritime transport. This separation removed the possibility of the network modelling river vessels that did not possess seaworthy attributes (such as a flat-bottomed barge) as being able to use maritime routes.

The locations where the vector polylines join form the major nodes of the network (see Figure 4.7). The nodes shown only represent the most prominent sites within the region.⁷⁷ At nodes where separate transport types intersected, network junctions were created which allowed transfer between them. These network junctions fell into the categories of Maritime to Land, Maritime to River, Maritime to Canal, River to Land, River to Canal, and Canal to Land (see Figures 4.8-4.13).⁷⁸

4.4.2 Creating the Network Dataset

With the network nodes and edges generated, it is then necessary to apply weights to them in the form of cost and time. The figures used to weight the model are listed in Table 4.6. These values are taken from De Soto 2019, with the addition of the cost and speed estimates for canal transport discussed in Section 4.3.1. Within each layer, the length of each polyline in the shapefile is generated in kilometres. This figure is then multiplied by the transport cost and divided by the speed to generate figures for the total cost and time to traverse each network edge using the values given in Table 4.7. For roads, these figures are subsequently altered by the slope modifiers outlined in Section 4.3.3 to generate new values. For rivers, downstream and upstream travel are distinguished through the use of *tf* (to-from) and *ft* (from-to) values respectively, allowing the assignment of separate values depending on the direction of travel. All these figures are stored in the attribute table of each layer's shapefile (see Figure 4.14). For network junctions, a transshipment cost is applied to all movement between rivers, the sea, canals, and land. The only exception is movement between rivers and canals, which was probably seamless and utilised the same vessels (see Section 3.1.4). Consequently, no transshipment cost is assigned to river to canal junctions. For all other junctions, the monetary cost of transshipment is 10 kg wheat and transshipment time is 12 hours. A second set of junctions are generated to model the

⁷⁷ There would have been other, smaller stops along both the river and terrestrial routes (for example the small wharf uncovered at Lago Tramonto), but these have been omitted due to the uneven nature of their discovery and to ensure the legibility of the model.

⁷⁸ Aquileia does not have a maritime to canal junction as its port was located on the river Natisone. Fluvio-maritime vessels would have needed to traverse the river first, at which point cargo could transfer to the canal system via the fluvial to canal junction highlighted in Figure 4.12.

Transport Type	Cost (kg wheat/T/km)	Speed (kmph)
Maritime	0.093	4.26
Fluvial (downstream)	0.33	2.51
Fluvial (upstream)	0.66	0.52
Canal	0.66	3.21
Overland	4.92	2.5

Table 4.7: The values for the monetary cost and speed of transport used within the network model.

transshipment of heavy cargoes. For this model, the monetary cost of transshipment is 100 kg wheat and the time 36 hours. Once again, river to canal junctions incur no transshipment penalty.

The multi-modal network model is created using ArcCatalog. Four layers of connectivity are created (sea-lanes, navigable rivers, roads, and canals), with network junctions enabling transfer between them at selected points (see above). Nodes for input sites, representing the points that goods entered the region, are selected. These are Altinum, Aquileia, Ariminum, and Ravenna on the Adriatic coast, and Genoa, Luna, Porto Maurizio, and Savona on the Ligurian coast. In addition, several inland sites are also selected to compare how goods might move out of the region. These are Aosta, Alba, Cremona, Milan, and Turin. From these, access surfaces are mapped for cost and time using the program's Service Area Index.⁷⁹ For cost, bands of 100 kg wheat are mapped, covering the entirety of the study area. For time, bands of 12 hours (representing the absolute maximum number of useable daylight hours) are mapped. The results of the analysis are outlined in the following section.

4.5 Results: Cost

4.5.1 The Adriatic Coast

Figure 4.15 maps the incremental cost of transport for a hypothetical 1000 kg cargo from all four Adriatic ports.⁸⁰ The maximum transport cost from the Adriatic ports to reach another part of the study area suggested by the model is 1800 kg wheat, 80% more than the value of the 1000 kg cargo.

The entirety of the Adriatic coast could be reached for less than 100 kg wheat, a reflection of the low-cost of maritime and para-littoral canal transport. The im-

⁷⁹ The Service Area Index creates vector polygons that map all accessible areas within a specified impedance from a set starting point or points.

⁸⁰ To ensure the legibility of the results, only the locations of the sites used in the analysis are included on the maps. Please consult Figure 4.1 for the locations of other sites mentioned.

portance of the para-littoral canals is reflected on the short stretch of coast where they are absent between Ravenna and Ariminum, where transport costs increase to 200 kg wheat. The para-littoral canal system between Aquileia, Altinum, and Ravenna, coupled with the absence of transshipment costs between canal and fluvial transport, allowed goods originating from these ports to rapidly access the Po-Veneto fluvial network. Bologna, Hostilia, and Padua are accessible for under 100 kg wheat, while major urban centres in the middle Po such as Brescia, Brixellum, Cremona, and Parma can be reached for a cost of under 200 kg wheat. Price continued to increase as transport progressed upstream. Centres at the very end of the river network such as Turin, Ivrea, and Alba cost twice as much to reach from the Adriatic coast as those in the middle river, with 400 kg wheat forming the maximum transport cost for sites situated on a river, lake, or canal. This was a cost of 40% of the total value of the hypothetical 1000 kg cargo. The high density of the Po-Veneto river network helped ensure that urban centres located on the valley floor that were not on navigable waterways (such as Chieri, Fidenza, and Novara) could be accessed for under a cost of 500 kg wheat. The great glacial lakes, particularly Lakes Garda, Como, and Maggiore, also provided corridors that allowed lower-cost movement into mountainous areas.

Transport costs sharply increase in areas where a navigable river was absent, particularly in the Alps and Apennines. 100 kg of wheat can pay for 151.51 km of upstream fluvial transport, as opposed to 20.32 km of overland transport over level ground, less if there is a gradient. This is clearly seen in the upper valley, where the cost of transporting one tonne of cargo from the Adriatic coast to Ivrea (400 kg wheat) doubles over a distance of 68 km overland to reach Aosta (800 kg wheat). This cost then doubles again to 1600 kg wheat in order reach sites on the other side of the Gran San Bernado Pass in the Rhône valley, such as Octodorus or Sedunum. The cost of this transport exceeds the value of the 1000 kg cargo by 60%. The high prices shown here are representative of the greater cost of overland transport and especially the challenge presented by gradient in mountainous areas.

4.5.2 The Ligurian Coast

Figure 4.16 maps the incremental cost of transport for a hypothetical 1000 kg cargo from all four Ligurian ports. The maximum transport cost from the Ligurian ports to reach another part of the study area suggested by the model is 2000 kg wheat, double the value of the 1000 kg cargo and 200 kg wheat more than the maximum transport cost from the Adriatic ports.

Transport costs from the Ligurian coast are far more uneven than those from

the Adriatic, with costs rapidly increasing as overland routes moved away from ports. It costs seven times as much to transport goods overland between Luna and Genoa as it does by sea, a product of the steep and difficult roads that follow Liguria's rugged coastline.

The Apennines present a significant cost barrier for overland travel, with prices varying between 400 and 700 kg wheat to traverse them. Beyond the mountains, the Monferrato, Langhe and Colline del Po hills force more circuitous routes to be taken to potential markets in the south-west of the region, such as Alba, Augusta Bagiennorum, and Pollentia, adding additional cost. At a minimum, these urban centres can be reached at a cost of 500-600 kg wheat, a cost of over half the value of the goods being transported. Of the Ligurian ports, Genoa and Savona seem to have been best placed from a cost perspective to access the Po valley, lying on or close to roads that crossed the Apennines which soon arrived at navigable rivers. Although Luna also sat upon a trans-Apennine road, the model suggests it is 300 kg wheat cheaper to transfer goods via boat to Genoa, cross the Apennines using the via Postumia, and send goods into the lower Po valley along the river network, rather than use the trans-Apennine road to Parma.

At the point that transport reached a centre with a navigable river, the waterways become the primary vector of travel. For example, it costs between 400 and 500 kg wheat to travel the approximately 71 km between Genoa and Tortona overland, however, a similar distance between Tortona and Cremona using the waterways costs less than 100 kg wheat. The lower cost of downstream transport allows goods moving from the Ligurian coast to reach ports on the Adriatic for under 700 kg wheat, up to a 200 kg wheat reduction on the cost of the same journey from an Adriatic direction. Moving off the valley floor and into the Alpine valleys and passes incur a similar penalty to that seen in transport from the Adriatic coast, with even less penetration achieved. Aosta can just be reached for 1000 kg wheat, equivalent to the value of the goods transported.

4.5.3 Inland Sites

The following figures map the incremental cost of transport for a hypothetical 1000 kg cargo from a selection of inland sites within Northern Italy. Figure 4.17 shows Aosta, Figure 4.18 Cremona, Figure 4.19 Milan, and Figure 4.20 Turin. The maximum transport costs from these inland sites to another part of the study area suggested by the model vary between 1600 and 2100 kg wheat.

Free of the need to overcome the steep mountain gradients of the Apennines or battle upstream against a river's current to gain access to the interior, sites located within the valley itself enjoyed lower transport costs to reach other areas

within the region. Cremona, occupying a central position in the valley and lying directly on the Po, was well placed to distribute goods across the valley at a low cost. Most places on the valley floor can be reached for under 300 kg wheat, less if they were on a navigable river. Transport originating from Milan is also similarly well placed to access most areas within the valley for under this price.

Inland sites clearly demonstrated the advantages of being on a navigable river and the possibilities offered by the low cost of downriver transport. For Turin, a site theoretically at the navigable limit of the Po, it is possible to travel as far as Cremona for 100 kg wheat and reach the mouth of the river for 200 kg wheat. In comparison, it costs between 500 and 600 kg wheat to access ports on the Ligurian coast. Conversely, the disadvantages of being away from navigable rivers are seen in the case of Aosta. A journey from Aosta to Ravenna costs just under 700 kg wheat, but 400 kg wheat of this (over half the total journey cost) is spent travelling overland down the Val d'Aosta to reach the river port at Ivrea. Once the transition to river transport had been made, it costs less than 300 kg wheat to travel the remaining distance via the water.

4.5.4 Heavy Cargoes

The following section examines transport costs in relation to heavy cargoes that were significantly more expensive to tranship and were more sensitive to changes in gradient. Figure 4.21 maps the incremental cost of transport with a 20% transshipment cost and triple slope cost modifier from all four Adriatic ports, while Figure 4.22 represents the same from all four Ligurian ports. The maximum suggested transport cost from the Adriatic ports is 2700 kg wheat, while from the Ligurian ports the maximum suggested cost is 3000 kg wheat. Both these maximum prices are 50% more expensive than the maximum cost of transporting a regular cargo.

The increase of transshipment cost from 10 kg wheat to 100 kg wheat has a mixed impact on the cost of transport from both the Adriatic and Ligurian coasts. From the Adriatic, most of the western valley is still reachable for under 600 kg wheat, however, costs once again rapidly increase as transport moved into the Alpine valleys and passes. The cost to reach Aosta from Ivrea increases from 400 kg to 700 kg wheat, with the cost of reaching the upper Rhône valley from Aosta then increasing from 800 kg wheat to 1300 kg wheat. Including the cost of river transport to Ivrea, the total cost of a journey from the Adriatic coast to Sedunum in the Rhône valley is 2500 kg wheat, a 90% increase on the price of 1600 kg wheat for a conventional cargo. From the Ligurian ports, the increased cost penalty applied to slope made crossing the Apennines a more

expensive endeavour. Crossing the Apennines from Genoa to Libarna increases by 100 kg wheat to 500 kg wheat (an increase of 25%), while the crossing from Luna increases by 300 kg wheat to 1000 kg wheat (an increase of 42%). For a conventional cargo, a price of 1000 kg wheat was sufficient to reach both Ravenna and Altinum from the Ligurian coast. Despite the high cost of transshipment, the most cost-efficient way for cargo from Luna to access the Po valley remains for it to be shipped to Genoa and then taken across the Apennines overland on the via Postumia. The increased costs incurred by the gradient of the overland route between Luna and Parma serve to further reduce its viability in terms of transport cost.

In both cases, the region's waterways remain the main axis of travel for Adriatic and Ligurian cargoes. From the Adriatic, for goods travelling outside of the 100 kg wheat range of each port, it remains cheaper to use the water network. From the Ligurian ports, it is only due to the presence of a river port at Tortona that transport is able to reach the Adriatic coast for under 1000 kg wheat. This would have been significantly more expensive if solely utilising overland transport. The continued reliance on water transport, despite the increase in transshipment cost, is reflective of the cost inefficiency of overland transport. The total transshipment cost of 200 kg wheat equalled the cost of 40.65 km of overland transport over even ground, while the distance travelled by upstream transport for an equivalent cost was 303 km. This allowed water transport to recoup its transshipment costs over a short distance.

4.6 Results: Time

4.6.1 The Adriatic Coast

Figure 4.23 maps the incremental time of transport for a hypothetical 1000 kg cargo from all four Adriatic ports. The maximum transport time from the Adriatic ports to another part of the study area suggested by the model is 300 hours, the equivalent of 25 days of travel during hours of full daylight.

The results for travel times within the region differ significantly from those for cost. Although the river network enabled travel over long distances at relatively low cost, the practicalities of fluvial navigation meant the road network presented a faster alternative. For transport originating from the Adriatic ports, most sections of the coast can be reached within 12-48 hours thanks to its maritime connections and the para-littoral canal system. However, moving beyond the coast, the main roads, in particular the via Aemilia and the via Postumia, form the quickest axis of travel, rather than the inland waterways. The slow speed

of upstream transport, coupled with the 12-hour delay caused by transshipment, meant it was unable to match the pace of road transport. For example, it takes 240 hours to reach Milan from the Adriatic coast using fluvial transport, as opposed to 156 hours using overland transport. Mountainous areas also form less of an impediment to the speed of transport when compared to cost, although still present the most time-consuming areas of the model to traverse (for example, it takes 264 hours to reach Aosta from the Adriatic coast, the equivalent of 22 days of travel during full daylight hours). It takes 48 hours of continuous travel to traverse the Alps across the Gran San Bernado Pass from Aosta or the San Bernadino Pass from the northern shore of Lago Maggiore.

4.6.2 The Ligurian Coast

Figure 4.24 maps the incremental time of transport for a hypothetical 1000 kg cargo from all four Ligurian ports. The maximum transport time from the Ligurian ports to another part of the study area suggested by the model is 240 hours, the equivalent of 20 days of travel during hours of full daylight. This is 60 hours less than the maximum transport time from the Adriatic ports, likely due to the Ligurian ports' less peripheral placement in the network.

For transport originating from the Ligurian ports, most sections of the Ligurian coast can be reached within 24 hours. The one exception is the mountainous stretch of coastal road between Genoa and Luna, which takes 36 hours of travel. While the Apennines form a major barrier to transport originating from the Ligurian coast in terms of cost, they do not provide a similar impediment to time. It is possible to cross the Apennines from Genoa and Savona within 48 hours, although the journey from Luna takes longer at 60 hours. Several major centres in the upper and middle valley, such as Turin, Pavia, and Piacenza, can all be accessed within 96 hours, although even this constitutes seven days of travel using full daylight hours.

Although terrestrial transport crossing the Apennines from the Ligurian coast quickly reaches several river ports, fluvial transport once again proves a slower alternative to overland. Although downstream fluvial transport theoretically travelled at a similar speed to overland transport, the 12-hour transshipment delay meant river vessels were never able to match the pace of terrestrial vehicles. However, while the road network remains the most time-efficient mode of transport to reach areas in the western valley from the Ligurian coast, from Cremona onwards the time difference between fluvial and overland becomes less pronounced. This is likely due to the cumulative effect of gradient reducing the speed of overland transport. Waterborne transport quickly begins to make up time once it reaches

the para-littoral canal system, with vessels using the canals arriving at Ravenna, Altinum, and Aquileia simultaneously with overland transport. However, the waterborne cargo have yet to tranship, which adds an additional 12 hours to their total time. The canal system plays a key role by allowing fluvial transport to move along the coast without needing to tranship onto a seaworthy vessel, with the fast speed attributed to canal transport allowing most of the coast between Altinum and Ravenna to be accessed within the same 12-hour time bracket.

As with the Adriatic ports, the mountainous areas of the Alps form some of the most time-consuming areas of the network to traverse. However, it is still quicker to travel to Aosta from the Ligurian coast (156 hours), than it is to reach Altinum, Ariminum, and Ravenna on the Adriatic coast (180-192 hours). Furthermore, Aquileia, located in the extreme east of the network, takes significantly longer to reach. From the Ligurian Coast it takes the same time (240 hours) to travel to the upper Adige and upper Rhône valleys as it takes to arrive at Aquileia.⁸¹

4.6.3 Inland Sites

The following figures map the incremental time of transport for a hypothetical 1000 kg cargo from a selection of inland sites within Northern Italy. Figure 4.25 shows Aosta, Figure 4.26 Cremona, Figure 4.27 Milan, and Figure 4.28 Turin. The maximum transport time from these inland sites to another part of the study area suggested by the model varies between 192 and 276 hours.

Once again, the greater velocity of downstream travel over upstream proves advantageous in enabling the fast movement of cargo from centres close to the high point of navigable river systems such as Turin. The impact of gradient on the speed of overland transport is also visible, with the waterways gradually gaining an edge over terrestrial routes. Sites in the upper valley such as Turin are able to reach the Ligurian coast in under 96 hours, although it still takes 168 hours to reach the Adriatic coast. In the Alps, it is comparable in time to reach the upper Rhône valley and the Po valley from Aosta, taking just over 48 hours. Transport originating from the city can reach large sections of the western and northern Alps in less time than it takes to reach centres such as Milan on the valley floor. Central locations in the network, such as Cremona and Milan, have the best coverage out of all sites within the model, with the entirety of the network traversable from Milan in under 192 hours.

⁸¹ Indeed, it may well have been faster to reach Aquileia from Genoa by sailing around the Italian peninsula than going overland.

4.6.4 Heavy Cargoes

The following section examines transport time in relation to heavy loads, cargoes such as stone that were significantly more time-consuming to tranship and more sensitive to changes in gradient. Figure 4.29 maps the incremental time of transport with a 36-hour transshipment time and triple slope modifier from all four Adriatic ports, while Figure 4.30 represents the same for all four Ligurian ports. The maximum transport time from the Adriatic ports suggested by the network model is 372 hours, the equivalent of 31 days of travel during full daylight hours and a 24% increase in total journey length compared to that of a conventional cargo. The maximum transport time from the Ligurian ports is 336 hours, the equivalent of 28 days of travel during full daylight hours and a 40% increase in total journey length compared to that of a conventional cargo.

The increase in transshipment time from 12 to 36 hours has a significant impact on transport originating from both the Adriatic and Ligurian ports. Reinforcing the patterns outlined above, the delay caused by transshipment makes it quicker to solely use overland transport when transporting heavy cargoes. The tripling of the time penalty applied to gradient has the most visible impact on the time heavy transport took to traverse the model. Indeed, the increase in the time spent traversing the network is solely due to the impact of gradient, as fluvial transport was bypassed by the analysis. The impact of the increased gradient penalty can be seen across the model, and it is most apparent in mountainous areas. The time spent crossing from Genoa to Tortona increases by 33% from 36 to 48 hours, while the crossing from Luna increases by 40% from 60 to 84 hours. In the Alps, traversing the Great St. Bernard Pass from Aosta to the upper Rhône valley increases by 60% from 60 to 96 hours, while crossing the Little St. Bernard Pass increases by 33% from 72 to 96 hours.

4.7 Discussion

The network analysis outlined above reveals the separate challenges faced by those transporting goods from the Adriatic and Ligurian coasts in reaching different areas of Northern Italy. Different transport modes offered various advantages and disadvantages in both cost and time, which the model threw into sharp relief.

Of all transport modes present in the network, fluvial transport was shown to have had the greatest impact on how cargo moved within the model. The low cost of upstream transport allowed sites such as Turin, lying in the far west of the valley and at the extreme limits of navigable waterways, to be reached for

under 400 kg wheat from the Adriatic ports. These sites acted as springboards for overland journeys into areas not accessible by water, which may otherwise have been prohibitively expensive to travel to from the Adriatic or Ligurian coasts utilising solely terrestrial transport. Indeed, upstream transport meant that it was cheaper to reach many sites in the western valley from the Adriatic coast, despite them being located significantly closer to the Ligurian coast. However, while it is undeniable that the Po and its tributaries formed cost-efficient routes into the interior of Northern Italy from the Adriatic, it is worth pointing out that, in large areas of the upper valley, there was less than 100 kg wheat difference in the cost of travel from the Adriatic and Ligurian coasts (see Figure 4.31). Consequently, the dominance of the Adriatic axis of transport over the Ligurian should not be assumed across the entirety of the valley.

Although upstream fluvial transport was responsible for reducing the cost of travel into the western areas of the valley, it did not have the same impact on transport time. From the Adriatic ports, the slow speed of upstream travel, coupled with a 12-hour transshipment delay at each end, meant it was quicker to travel overland. In comparison, downstream transport offered a significant advantage in both cost and time, most clearly seen in transport originating from the Ligurian coast. While most areas of the Adriatic coast could be reached from the Ligurian ports for under 700 kg wheat, the return journey utilising upstream travel would have cost between 100-200 kg wheat more. This difference may help explain the presence of some Western Mediterranean goods in the eastern valley, yet the complete absence of Adriatic goods at Ligurian sites.⁸²

While the model presents overland transport as having an advantage over upstream fluvial transport in terms of time, the results are somewhat misleading. Fluvial transport had additional advantages that could not be displayed in the model, notably the superior cargo capacity a river barge had over a wagon. While a wagon might have been able to carry a load of 0.5-2 t, wrecks from the region show that fluvial vessels in this area certainly had capacities of 12-15 t, and fluvial wrecks from elsewhere in the Roman world have been recorded with cargoes of upwards of 100 tonnes (see Section 3.1.4). Although a wagon and its cargo might outpace a barge making its way upstream initially, the wagon would then have to make multiple trips to deliver the same quantity of cargo the barge transported in one. In this case, upstream fluvial transport would possess a considerable time advantage over terrestrial transport.

Moving away from navigable rivers, transport became more costly and (in some cases) time-consuming. This was especially true for the more mountainous

⁸² Bruno (1998); Melli (2004); Melli and Pasquinucci (1998).

areas of the region. In particular, the northern Alps formed some of the most expensive areas to reach from both a cost and time perspective. While the entirety of the valley floor was traversable for well below 1000 kg wheat, cost rapidly increased as soon as attempts were made to scale any of the major Alpine passes such as the San Bernadino, the Great St. Bernard, and the Little St. Bernard, where slopes frequently exceeded 10%. Indeed, for peripheral sites in the Alps, such as Aosta, there may not have been much difference in cost and time between transporting goods from Gaul (in particular goods originating from the Rhône valley) and transporting goods from the Adriatic and Ligurian seaboard.

Gradient affected both the cost and speed of overland transport, although the path of roads tried to limit this as much as possible. In mountainous areas, roads routinely followed the path of valley floors before ascending and, where this was not possible, infrastructure such as bridges, viaducts, and buttresses helped to reduce the gradient (see Section 3.2.2). Of course, when ascending an Alpine pass, there was a limit to how much could be done to reduce the impact of slope, reflected in the high cost these areas of the model incur. While some areas of the Apennines, such as the road between Luna and Parma, were also significantly affected by gradient, the *via Postumia*, the main trans-Apennine road between Libarna and Genoa, followed the valley of the Torrente Scrivia for much of its path. This reduced the route's elevation and slope, which, in turn, reduced the cost and time of transport using it to cross the Apennines. This allowed goods travelling from the Ligurian coast to arrive in the south-west of the Po valley far quicker than those originating from the Adriatic coast, with their journey having cost less or equal to that of the Adriatic. Finally, the role of even minor slopes in adding cost and time to journeys has already been highlighted above, with small increments soon tallying up. When it came to heavy cargoes, the impact of slope on price doubled the cost of overland transport in some areas.

Unsurprisingly, sites located at the centre of the network had good connections to most areas of the model. Such sites would have been well-placed to act as redistribution centres, playing a key role in the dissemination of goods into local markets.⁸³ There is also the question of exports, which will be addressed in later chapters (see Section 9.3). However, the importance of the connections between inland sites and beyond was not just economic. From a communications perspective, travellers from Cremona and Milan (moving at an average pace of 2.5 kmph) could traverse the entire network in under 240 hours (or 20 days of travel during daylight hours), an advantageous position to have as an important regional centre. Indeed, during the Year of the Four Emperors, Cremona would be

⁸³ For example, Cremona was known to have hosted a major fair/market each October which, according to Tacitus (*Histories*, 3.30-32), attracted people from across Italy.

the location of two decisive battles between Othonian and Vitellian, and Vitellian and Flavian forces, with the town being used as an assembly point for the legions on various sides.⁸⁴ The town's excellent connections (six major roads, among which were spurs of the *via Aemilia* and *via Postumia*, led out of the town, which also sat directly on the Po) made it a natural meeting point and an important location to control for movement and communications.

Although the network analysis focused on inland regions, the model suggested that maritime routes retained an important role in the movement of cargo in coastal areas. In the case of the Ligurian ports, they allowed cargo to be transported quickly from ports such as Porto Maurizio and Luna, to harbours better placed to begin the overland journey across the Apennines. This also worked in reverse, where cargo could be transferred from overland to maritime transport to circumvent the expensive and time-consuming journey along the Ligurian coast road. The cost-efficiency of maritime transport more generally often meant that if one port on a coastline could be reached, then other ports on that seaboard could normally be accessed within the same or adjacent cost bracket. The density of maritime, canal, and fluvial routes along the Adriatic coast contributed to the low cost and quick times associated with navigating this area of the network. An interesting outcome of the model was that, along the Adriatic coast, the maritime route was cheaper and quicker than the para-littoral canal system in most scenarios. Although this may be a consequence of the data used to estimate the cost and speed of canal transport, there may be other, less tangible reasons for the canals' construction. Indeed, it is possible that reducing the cost and time of transport along the coast were not significant motivations for their construction. As has been suggested earlier (see Section 3.1.2), increasing the safety of vessels moving along the coast may have been main purpose of the para-littoral *fossae*, providing a route that circumvented maritime hazards and avoided having to traverse the dangerous mouths of the Po to access the river network.

Transshipment penalties had a mixed effect on the cost and speed of transport. A 2% transshipment cost does not seem to have significantly impacted smaller cargoes, as the high cost of overland transport enabled waterborne goods could easily absorb the additional price. The same, however, cannot be said for time. The 12-hour delay involved in the loading and unloading of waterborne cargo formed a significant barrier to switching transport modes, one that would be further compounded upon its increase to 36 hours when modelling heavy cargoes. Although downstream transport was able to make up time due to the impact

⁸⁴ Tacitus, *Histories* 2.22-25; 3.16-21; 3.30-32. Piacenza, similarly favourably located but on the southern bank of the Po, was also the site of a preceding siege during the Othonian-Vitellian conflict.

of slope on the speed of overland travel, the slow pace of upriver travel did not afford similar possibilities, making it uncompetitive to terrestrial transport timewise. When the cost of transshipment was increased to 20% for heavy cargoes, the pattern did not significantly change (although overall prices were, of course, higher). The waterways remained the dominant axis of travel despite the large increase in cost, due to the high price of overland transport. Of course, the model cannot account for quirks in human nature and non-quantifiable factors that may have influenced decision-making. For example, although high cost and time did not pose a barrier to transshipment in the model, the transfer of goods and materials posed significant risks, especially with large, bulky loads such as stone and marble that were difficult to handle. The potential for breakage or loss of cargo increased with each transfer, and it is questionable whether shippers would have risked transshipping heavy cargo if it could have been avoided.

4.8 Conclusions

Using network analysis to examine the Roman transport network of Northern Italy revealed the differing ways cost and time affected the range of transport. Far from being a difficult and prohibitively costly region to access and traverse, the results show that there was good accessibility for large areas of the valley from coastal regions. The model largely confirms the importance of waterways in facilitating cost-efficient travel within inland regions, with the Po and its tributaries forming an important axis for transport due to their extent and density across the valley floor. Away from fluvial and maritime routes, the expense of overland transport, compounded by gradient, rapidly increased costs. The model also revealed significant differences between the most cost-efficient and time-efficient routes. The time analysis demonstrated that the shortest route was not always the cheapest, and that overland transport could often be more time-efficient than fluvial.

Crucially, the model challenges the assumption that the Apennines made transport from the Ligurian coast into the Po valley uneconomical. Although the Apennines did form a significant obstacle in terms of cost for goods arriving from Ligurian ports, this was matched by the cost of transporting goods from the Adriatic coast into the upper reaches of the valley. This presents the question as to whether different areas of the valley may have been linked into either Western (served by the Ligurian ports) or Eastern (served by the Adriatic ports) Mediterranean markets. Although the model suggests that, in certain areas, it was possible for goods travelling over the Apennines to compete with those com-

ing up from the Po in terms of transport cost, the question remains as to whether or not there was specific demand to make this journey worthwhile. The proximity of Adriatic production areas to the study area and the demands from other, more accessible markets in the west for goods passing through the Ligurian ports, may have made the trans-Apennine journey unappealing to potential traders.

While the network model developed here creates several scenarios for how cost and time affected Roman transport, it exists as a purely heuristic device. Network models, as theoretical representations of past behaviour, cannot form a replacement for archaeological evidence. Instead, they must be used in combination with other material to test the validity of their results. In the second part of this thesis the distribution and provenance of ancient material evidence from across Northern Italy are analysed. These results are then compared against those of the network model in the third part of thesis.

Part 2: The Material Analysis

Chapter 5

Methodology

The following section of the thesis analyses the chronological and geographical distribution of three Roman material datasets across Northern Italy. Material data preserved in the archaeological record act as proxies for trade during the Roman period, in the absence of other evidence.¹ The material chosen for analysis in this thesis are amphorae, red-slipped finewares, and decorative stone. Ideally, an even greater array of artefacts would be brought to bear on the analysis, such as metal, lamps, glassware, and animal bones, but due to the length and time constraints of this thesis it was necessary to concentrate on the best-published and most available material. Amphorae, finewares, and decorative stone represent three distinct types of consumption within the Roman world. Amphorae primarily carried consumables, items such as oil and wine that were essential to the day-to-day diet and would be purchased repeatedly. In contrast, finewares, though widely represented across the strata of Roman society in archaeological excavation, were a non-essential item, an amenity rather than a necessity. Decorative stone and marble were luxury items, bulky and expensive one-off purchases that were the preserve of the wealthy or civic projects. The different patterns in the geographic and chronological distribution of these goods serve to contrast the varying levels of trade within Northern Italy and the mechanisms behind it.

Although scholarship on Roman Northern Italy has a long history of analysing trade patterns using material evidence, this has mainly occurred on a site-by-site basis and has never progressed beyond limited integration at the level of *so-printendenza* jurisdiction.² Prior studies have primarily utilised amphora and

¹ For example, sales records, contracts, and manifests only rarely survive in the archaeological record (for example the shipping contracts from the Fayum and Oxyrhynchus discussed in the previous chapter (see Section 4.3.2)). A plethora of proxy data has been applied to the study of the Roman economy, some more successfully than others. For a discussion of proxies, their potential and their shortcomings, see Greene (2005); Scheidel (2009); Van Oyen and Pitts (2017); Verboven (2021); Wilson (2009a); (2009b); (2014).

² This analysis most commonly takes place within the assemblage report itself, focusing on the specific trading connections of the site. However, there have been cases where researchers have

fineware data, while engagement with stone and marble assemblages has been more limited. For ceramics, the diffusion of some specific vessel forms, such as Lamboglia 2 and Dressel 6A amphorae or sigillata so-called Sarius and Aco cups, have been mapped at a regional level, but the intensity of their distribution has seldom been analysed and tends to be unquantified.³ For stone, the emphasis has primarily been on the distribution of some locally quarried lithotypes, such as Euganean trachyte or Verona Rosso, rather than imports.⁴ Mapping the spread and provenance of each vessel form and lithotype across the region will highlight the multiple levels and directions of trade occurring within Northern Italy, exposing the role that cost and choice played in the selection of goods within each assemblage. A quantified study that integrates amphora, fineware, and decorative stone data at a regional level has been previously lacking, and will be beneficial in understanding inland trade in Northern Italy and the mechanisms of inland trade more generally. An analysis of material distribution across the entirety of the region will provide new insight into the relationship between the coastal regions and their hinterland, as well as areas further inland, which have been previously assumed as marginal and difficult to access.⁵ Archaeology has, at times, suggested that sites located in coastal regions had more diversity in their imports; with the goods they consumed travelling a minimal overland distance due to their proximity to maritime ports.⁶ While the economic integration of coastal areas with other regions of the Roman Empire cannot be doubted, how far did this connectivity extend inland?

Four potential axes of trade existed within Northern Italy: the first was along the Adriatic coast, the second along the River Po, the third across the Ligurian Apennines, and the fourth across the Alps (the latter conceivably sub-divided into western and northern axes). The valley's connection to the Adriatic and its proximity to the Ligurian Sea allows the opportunity to examine the potential effect that two alternate maritime entry points for imports, located at opposite ends of the valley, had on material distribution. The Ligurian ports were in

tried to expand this analysis to cover multiple sites, such as for Novara and Vercelli in Piedmont (Spagnolo Garzoli et al. (2008)), and for Cremona and Calvatone in Lombardia (Mariotti et al. (2008); Volonte et al. (2008)).

³ For example, Cipriano and Mazzocchin (2012); (2019); Carre et al. (2014); Gabucci (2017).

⁴ For example, Calzolari (2003); Poletti Ecclesia (2019); Zara (2018). Gabelmann's (1973) study of sarcophagi is an important exception.

⁵ Northern Italy has repeatedly been described as a marginal and isolated area of the Roman Empire, principally by Anglophone scholarship (see Section 1.2). See Walsh (2008); (2014) for a wider discussion of concepts of marginality in the Mediterranean. Horden and Purcell's (2000) *The Corrupting Sea* helped to establish a movement of thought that emphasised the role of ports and coasts in connecting the disparate regions of the Mediterranean, with Rice describing ports as the 'pinnacle of market connectivity' in the Roman world (Rice (2012), 60, n. 187).

⁶ For example, Bonifay (2004), 451-2; Leitch (2011), 185-86; Morley (2007), 27-29; Russell (2013), Chapter 5; Tchernia (2016), 90-94.

close vicinity to sites in the south-west of the study area, but their goods had to cross the Apennines to enter the Po valley. Conversely, goods arriving via the Adriatic ports had a greater distance to travel to reach the west of the valley, yet the flatter terrain and fluvial connections may have resulted in an easier and cheaper journey compared to the goods crossing the Apennines. Away from the Adriatic and Ligurian seas, the Alps formed the land border between Northern Italy and the northern provinces. These mountains presented a significantly larger obstacle than the Apennines to overland trade but one that was not necessarily insurmountable.

This chapter outlines the methodology used to analyse the assembled amphora, fineware, and decorative stone data gathered from Northern Italy. The strengths and the flaws of the data, which vary between material types, are discussed, alongside ways to account for and overcome them. The steps taken to clean and standardise the data for analysis are outlined, together with the values used for analysis between each site. Finally, the individual quantitative methods used in the analysis are presented. The locations of sites mentioned within this chapter can be viewed in Figure 5.1.

5.1 Selecting the Data

The assemblage of material gathered here is the largest corpus of Roman data so far applied to the study of trade in Northern Italy. Across the three datasets of amphorae, finewares, and stone, 46,647 individual pieces of material, assembled from thirty-seven sites across the region, were compiled for analysis (see Figure 5.2). While a powerful tool, the dataset is not without flaws. Before embarking on any analysis, an examination of its origins, strengths, and weaknesses, is necessary. Over the past fifty years, extensive archaeological investigation, including both rescue and research excavation, has recovered a vast body of Roman material across Northern Italy. Not all of this evidence has been studied and published, but the scope of the proposed analysis here meant it was necessary to consult only published assemblages.⁷ Published assemblages varied in their quality and quantity across the study area. With little to no standardisation, they often reflect the publishing styles and practices of the region and times in which they were compiled.

In terms of the quantity of assemblages available for analysis, the reliance on published material meant that the spread of data is somewhat uneven. Although there is good overall coverage at a regional level, some areas are better

⁷ Many excavations remain unpublished or partially published across the region.

represented than others. In particular, the extreme west and east of the study area have a high number of published sites, in part due to the proactiveness of their *soprintendenze* in publishing their excavations. Meanwhile, site assemblages from the middle of the Po valley between Cremona and Industria are published to far lower extent. The problem of coverage is further compounded when the quantity of material per assemblage is taken into account. To achieve a rigorous level of analysis using the methods outlined in Section 5.3, a minimum sample size of thirty sherds/fragments is needed. Sites with smaller samples than this have the potential to produce misleading results and so were excluded from the analysis, with most of the sites omitted being smaller, rural settlements. These rural sites were frequently published in less detail than their urban counterparts, with few examples of quantification. As a result, it was decided to focus the analysis solely on urban assemblages, which were often the best published and contained a greater quantity of material.⁸ For instance, large infrastructure or research excavations, such as the MM3 excavations in Milan or the excavation of the Canale d'Anfore at Aquileia, often produced upwards of 1500 sherds of ceramic.⁹ In contrast, smaller, targeted interventions, such as those at Ravenna, might produce under a hundred sherds, though still enough to meet the minimum threshold for analysis.¹⁰ Even so, some urban sites with quantified assemblages, such as Parma and Susa, had to be discounted because their data were not of sufficient quantity.¹¹ Furthermore, the decision to focus on quantified assemblages meant that some important sites were excluded from the analysis. There are unfortunately no quantified assemblages available for study from cities such as Pavia and Piacenza, two major centres located directly on the Ticino and Po. Likewise, the absence of quantified amphora and stone datasets from Turin, the most westerly urban centre on the Po and at the supposed navigable limit of the river, leaves a regrettable gap in the analysis.¹²

Although a body of quantified material datasets from Northern Italy exists, comparing assemblages within each dataset was not a straightforward task. Below, some of the challenges faced in comparing quantified studies of ceramic and

⁸ While it can be argued that the inclusion of rural sites is essential in order to fully understand how goods are circulating on a regional basis, this study is primarily concerned with the initial bulk imports into Northern Italy. It is probable that most imported goods travelled through urban centres before being redistributed out towards rural areas, meaning that any overall trends in assemblage provenance should be robust.

⁹ Auriemma and Degrossi (2017); Bruno and Bocchio (1991).

¹⁰ For example, Fabbri et al. (2004); Guarnieri et al. (2018); Tempesta (2018); Zanda (2011).

¹¹ Brecciaroli Tadorelli (1990); Corti (2012a); (2012b); (2012c).

¹² There is a large corpus of amphorae from the excavations of Piazza Castello and the Giardini Reali in Turin, conducted between 1991 and 2000. However, the assemblage is still in the course of publication, with only the forms and quantities of Eastern imports so far having been released (Quiri (2009); (2015)).

Provenance	Percentage (sherds) n=5	Percentage (MNI) n=2	Percentage Difference
Adriatic	33.33	50	+16.66
Tyrrhenian	66.66	50	-16.66

Table 5.1: Differences in the percentage of each amphora provenance from Brescia during the Late Republic when counted by Number of Sherds and MNI. Data from Bruno and Bocchio (1991).

lithic material are outlined, alongside the solutions adopted.

5.1.1 Ceramic Assemblages

There are numerous obstacles to comparing ceramic assemblages, not least of all deciding which unit of quantification to use for comparison.¹³ The unit of quantification is something which often varies from publication to publication, with common methods of including minimum number of individuals (MNI), the number of rims, bases, and handles (RBH), sherd weight, and number of sherds. MNI offers the most accurate measure of the quantity of vessels within a site and would have been the preferential unit to use. Unfortunately, while this measurement was present in some publications from Northern Italy, it was absent from the majority. In a significant number of assemblages, the data for specific fragment types (i.e. walls, handles, bases, and rims) was also missing, meaning that it was not possible to calculate the MNI retrospectively for these sites. Number of sherds per vessel was the only measurement available across the entire range of publications and, consequently, this was the measurement selected for analysis. As a result, a degree of caution must be exercised when looking at the results. In Tables 5.1, 5.2; and 5.3, the provenance of vessels by percentage for Brescia are displayed, using both the number of fragments and the minimum number of individuals.

As can be seen, there is a small amount of variation in results from the first-second centuries AD, with changes in values being between -5.36% and +3.89%. However, the levels of variation between results from the Late Republic and the third-fifth centuries AD were, on average, much higher. In terms of the Late Republican assemblage, the low number of surviving vessels mean small changes to count numbers result in large percentage changes. Indeed, for Brescia, only five fragments of Republican amphora survive, leading to the high level of variation between the measurements and demonstrating the importance of the threshold

¹³ For a summary of the problems associated with using amphora data, see Orton (2009); Peña (2007a); Wilson (2009a), 229-38.

Provenance	Percentage (sherds) n=248	Percentage (MNI) n=110	Percentage Difference
Adriatic	58.46	58.71	+0.25
Eastern	31.04	25.68	-5.36
Iberian	4.83	4.57	-0.26
North African	4.43	8.25	+3.82
Tyrrhenian	1.2	2.75	+1.55

Table 5.2: Differences in the percentage of each amphora provenance from Brescia during the first-second centuries AD when counted by Number of Sherds and MNI. Data from Bruno and Bocchio (1991).

Provenance	Percentage (sherds) n=675	Percentage (MNI) n=363	Percentage Difference
Eastern	49.77	13.77	-36
Iberian	2.22	3.58	+1.36
North African	41.33	79.33	+38
Tyrrhenian	6.66	3.3	-3.36

Table 5.3: Differences in the percentage of each amphora provenance from Brescia during the third-fifth centuries AD when counted by Number of Sherds and MNI. Data from Bruno and Bocchio (1991).

of thirty sherds/fragments needed for analysis. It is obvious that the greater the difference between the total number of fragments and the total MNI, the greater the margin of error but, unfortunately, these data are absent for the majority of assemblages used in this study. Consequently, a margin of error must be accepted when using number of sherds as a unit of quantification.

The survival and publication of the ceramic data are very uneven across the Roman era. Data from the first-second centuries AD are the best studied and were available across all thirty-six sites with ceramic assemblages. Unfortunately, intact Republican deposits of ceramics are rare, with most assemblages returning under ten fragments. The situation is similar for data from the third-fifth centuries AD, and is further hindered by a publication bias against material dated to later periods. Assemblages from the third century AD onwards are far less comprehensively studied, with most of the data being described in only a tokenistic manner, if at all; a greater focus is typically given to the earlier Late Republic and Early Imperial periods. Where material specialists with Late Antique or Early Medieval experience, such as Bruno or Bocchio, have examined assemblages, the third-fifth centuries data is presented in greater detail, but such cases are rare.¹⁴ Consequently, data from the Republican period and the third-fifth centuries AD

¹⁴ For example, Bruno (2008); (2002); Bruno and Bocchio (1991); (1999); Massa (1999); Morandini (2008b).

are absent for some of the sites within this study.

While the main focus of the ceramics analysis was on the provenance and form of the vessels themselves, there was, at times, an epigraphic aspect to the amphora and sigillata data by way of stamps. Although these were not present on every fragment or recorded in every publication, they offered another angle through which to approach and analyse the data.¹⁵ However, it is worth highlighting that, in some cases, fineware publications only recorded stamped sigillata (for example, the assemblages from Julia Concordia and Modena), potentially leading to an over-representation of finewares from the Italy and Gaul from the first centuries BC and AD which were more likely to mark their ceramics.¹⁶ In a similar vein, some forms of amphora, such as the Dressel 6A, Dressel 6B, and Dressel 20, were more widely stamped, resulting in any analysis revealing more about their specific distribution patterns rather than overall trends in trade.¹⁷

5.1.2 Decorative Stone Assemblages

The stone datasets from the region presented similar challenges to the ceramic data when it came to quantification. The majority of assemblages are comprised of marble veneer (although not all datasets distinguish between wall revetment and floor panels). In some cases, architectural elements (such as small columns or fragments of cornicing) and sculpture were included; however, these were present in small quantities. Sarcophagi provided another possible dataset for analysis, often published separately from other elements of stone assemblages. Unfortunately, sarcophagi were rarely present at sites in the quantities needed to meet the threshold for analysis.¹⁸ Furthermore, comparisons between stone and marble assemblages are not as straightforward as those using amphora and fineware datasets. Whereas an assemblage of amphora or fineware, regardless of the context, may be broadly indicative of what was routinely available at a site, the same cannot be said for stone.

Stone and marble elements were luxury items, bought and designed for a single specific purpose in comparison to widely available amphorae and finewares that saw repeated consumption. Although stone and marble veneer used in pri-

¹⁵ For example, the analysis of the provenance and distribution of amphora stamps and *tituli picti* across the Roman world revealed evidence for different trade networks in the northern provinces and the Mediterranean (Rubio-Campillo et al. (2017); (2018)).

¹⁶ Van Oyen (2016), 16. The practice of stamping sigillata also seems to have begun to fall out of fashion from the Flavian period onwards, perhaps suggesting a change in the organisation of production (Mongardi (2014), 237).

¹⁷ Carre et al. (2014), 424-25; Fulford (2018), 301-03.

¹⁸ For example, Gorrini and Robino (2015) for the sarcophagi at Pavia. Gabelmann (1973) produced an inventory of white marble sarcophagi in the Northern Italy, although the number of sarcophagi present at each site were routinely under four examples.

vate contexts, such as a townhouse, might be indicative of the general availability of some stone types, the issue becomes more complex when taking into account large, public structures.¹⁹ Monumental architecture, such as the *capitolia* of Brescia and Verona or the theatre at Augusta Bagiennorum, were not subject to the same budgetary limitations as private structures. As civic projects, the commissioners would have had more control over the stone and marble used in their construction and decoration. This is particularly applicable to the commissioning of large architectural elements such as columns, capitals, and entablature. Although the unique requirements such commissions entailed provides more substantial evidence for direct trading links between consumers and quarries than the presence of imported veneer and pavement, they reflect different mechanisms of consumption than those in private contexts. Although assemblages of several different categories of stone and marble material were available from sites across Northern Italy, decorative stone (in the form of veneer and floor panels) was the most commonly quantified and best published. Consequently, this was the category of stone and marble material chosen for analysis. Examining a single category of material helped to ensure a degree of standardisation in the comparison and eliminated the risks involved in giving a fragment of wall revetment the same weighting as a column capital in the analysis.

As with ceramics, there are several possible units of quantification for decorative stone. The preferable comparative unit would be the total weight of each stone and marble type present in each assemblage, as this offers a more accurate indication of the quantity of material at each site. Unfortunately, weight was only recorded for one assemblage within the study area, that of the *Domus* of ‘Bestie Ferite’ and ‘Titus Macro’ at Aquileia.²⁰ Another possible quantitative measurement available was the total volume of each lithotype. This unit is not without its own problems (namely the difficulty of achieving an accurate volumetric measurement for highly irregular objects) and forms an uncommon method of quantification.²¹ For assemblages that solely contained wall revetment or floor panelling, the total surface area of a lithotype might be included in cm^2 , but this measurement was also absent from many sites.²² The one quantitative measure-

¹⁹ It is possible some stone and marble veneer was imported pre-cut and stockpiled by craftsmen specialising in its application (see Section 8.1). See also, Peacock and Maxfield (1997), 213–14; Russell (2013), 234–53.

²⁰ Previato and Mareso (2015). A total weight for the stone assemblage from the *Capitolium* of Verona was also available, however the weights for individual stone and marble types was not provided (Bocconcello (2008)).

²¹ The only assemblage to include a measurement of stone and marble volume was the MM3 excavations in Milan (Terracina (1991)). Minato (2018) also included the measurements necessary to work out volume for the architectural elements and sculpture recovered from the Altinum survey.

²² The stone and marble assemblage from the theatre at Augusta Bagiennorum included these

Provenance	Percentage (fragments) n=240 fragments	Percentage (volume) n=17,155.09cm ³	Percentage Difference
Alpine	15.83	39.89	+24.06
Asia Minor	29.16	24.3	-4.86
Central Italy	4.16	7.37	+3.21
Egypt and North Africa	22.08	10	-12.08
Gaul	1.25	1.39	+0.14
Greece and the Aegean	27.5	17.15	-10.35

Table 5.4: Differences in the percentage of each stone provenance from Milan when counted by Number of Fragments and Volume. Data from Terracina (1991).

Provenance	Percentage (fragments) n=1075 fragments	Percentage (weight) n=100.377kg	Percentage Difference
Asia Minor	40.37	51.08	+10.71
Central Italy	9.86	18.07	+8.21
Egypt and North Africa	8.55	5.66	-2.89
Gaul	0.74	0.18	-0.56
Greece and the Aegean	40.46	24.97	-15.49

Table 5.5: Differences in the percentage of each stone provenance from Aquileia when counted by Number of Fragments and Weight. Data from Previato and Mareso (2015).

ment that was available across all assemblages was the number of fragments of each stone and marble type. While providing a starting point for analysis, using the number of fragments as an indication of the total quantities of stone present at a site is problematic. The uneven nature of fragmentation means that two fragments, while given equal weight on paper, might be vastly different in size. Tables 5.4 and 5.5 show a comparison between the number of fragments and the weight of stone (at Aquileia) and the volume of stone (at Milan), displaying the disparity between the two. As the number of fragments was the only measurement available across all datasets, this was selected as the unit of comparison despite its flaws. However, the possibility of over-representation and under-representation of some stone types caused by comparing fragments of different sizes remained.

While this section has highlighted many flaws with the material datasets, this does not mean they are unusable. New insights into the provenance of the amphorae, finewares, and decorative stone, and how they circulated within Northern Italy can be gained from them, so long as they are approached in a critical manner with due attention to their flaws. The methodology for studying the material, from entering each fragment into a database to running the quantitative analysis, is outlined in the following section.

measurements (Rulli (2008)).

5.2 Preparing the Data

To synthesise and prepare the material assemblages for analysis, their details were entered into individual Microsoft Excel spreadsheets (available in Appendix B). Each sherd/fragment was assigned a unique ID, with its site and find context also recorded. If no context was given for the find, it was entered as ‘Unknown’. The publication containing the original data was also listed. Other information added to each entry was dependent on the type of material. Much of the data required significant ‘cleaning’ before entry to allow comparison between assemblages, the details of which are outlined below.

5.2.1 Amphorae

Where possible, the vessel form assigned by the publication was used for each sherd. One of the challenges faced by studies utilising ceramics is the number of competing typologies developed over the past century, leading to single vessels having multiple overlapping classifications.²³ Within the database, the most commonly used classification for a vessel form was adopted in order to reduce possible confusion and ease comparison between the assemblages. Concordances between typologies can be found via the University of Southampton Archaeology Data Service.²⁴ Where a publication could not decide if a fragment belonged to one vessel form or another, the number of uncertain fragments was split between the proposed forms according to the ratio between them found elsewhere in the assemblage.²⁵ Some vessels found within the region have only been assigned typologies relatively recently, most notably the flat-bottomed Forlimpopoli type produced between Forlì and Ariminum.²⁶ Earlier published assemblages often refer to ‘*anfore a fondo piatto*’ with a Northern Italic origin, which probably equate to Forlimpopoli amphorae.²⁷ Given the uncertainty of this attribution, it was decided to class both Forlimpopoli amphorae and vessels referred to as having a ‘*fondo piatto*’ as Flat-Bottomed Italic amphorae, rather than impose a new

²³ For example, those of Beltràn, Dressel, and Lamboglia.

²⁴ https://archaeologydataservice.ac.uk/archives/view/amphora_ahrb_2005/info_intro.cfm (Accessed 01/01/2022).

²⁵ For example, if there were 15 vessels of uncertain Dressel 6A/Lamboglia 2 form, and there were 10 confirmed Dressel 6As and 5 confirmed Lamboglia 2s present elsewhere in the assemblage, then the 15 vessels would be split 10/5 between the Dressel 6A and the Lamboglia 2 along the 2:1 ratio. This mostly occurred between the forms Lamboglia 2, Dressel 6A, and Dressel 6B, which are morphologically similar. See, for example, Dobrevá (2013).

²⁶ The form was first proposed in the late 70s after the discovery of a furnace near Forlimpopoli (Aldini (1978)). The typology was then developed and refined over the following twenty years. See Aldini (1989); (1995); and (1999).

²⁷ For example, Acari (1996), 187; Bruno and Bocchio (1991), 272; (1999), 233; Cipriano and Ferrarini (2001), 23.

typology on vessels from earlier publications. Finally, fragments for which the vessel form was unknown, but whose area of production could be traced through fabric analysis were grouped together by their origin. Unidentified fragments and vessels with no known typology that lacked a secure origin were grouped as Unknown.

Each fragment was assigned a geographical location for its probable production area. In total, there were six broad provenances for the amphora circulating in Northern Italy during the Roman period. The first was ‘Adriatic’, encompassing vessels produced in the coastal hinterland of the Adriatic Sea. The second was ‘Eastern’, containing vessels from the Aegean, Asia Minor, and Palestine. The third was ‘Iberian’, encompassing vessels from the provinces of Baetica, Lusitania, and Tarraconensis. The final three origins were vessels from Southern Gaul, the coast of North Africa, and the Tyrrhenian coast. While in some cases, a more specific provenance was available for the vessels, using these would have obscured the overarching patterns in the data. It is also worth mentioning that included within the Adriatic category are vessels which are known to have had some production along the Adriatic coast of Northern Italy. These included examples of Dressel 2-4, Dressel 6A, Dressel 6B, and Flat-Bottomed Italic amphorae. The evidence mainly comes from fabric analysis, as there is so far little evidence for kiln sites within the region.²⁸ However, fabric analysis is absent from many of the assemblages, making it impossible to ascertain whether such vessels originated from the eastern Northern Italy or elsewhere within the Adriatic in the majority of cases. Furthermore, the Dressel 6A, and Dressel 6B are known to have been predominantly manufactured elsewhere within the Adriatic (see Figure 5.3).²⁹ Consequently, without the information to distinguish the production area of these vessels for all assemblages, it was decided to group them within a broad Adriatic provenance, rather than split them between an Adriatic and new ‘Northern Italic’ category.

A probable contents was assigned to each amphora, representing the most likely product to have been transported within the vessel. Possible commodities consisted of wine, oil, fish products, olives, fruit, *defrutum*, and alum. However, expanding evidence for reuse, both within the region and across the Roman

²⁸ The only known kiln sites are a Dressel 2-4 kiln at Reggio Emilia and several Dressel 6A kilns in the vicinity of Parma. No Dressel 6B kilns have been discovered within the Po-Veneto plain. See Cipriano and Mazzocchin (2012), 241-43 and Pellegrini et al. (1996).

²⁹ Dressel 6Bs seem to have been predominantly manufactured in Istria, with known kiln sites at Fažana and Loron (Cipriano (2009), 176; Cipriano and Mazzocchin (2012), 244). Cisalpine production of the Dressel 6B form seems to have entirely collapsed by the middle of the first century AD. See Cipriano and Mazzocchin (2012); (2019) for a good summary of the manufacture and circulation of these vessels.

Period	Chronology
The Late Republic	100 BC - 28 BC
The First-Second Centuries AD	27 BC - AD 200
The Third-Fifth Centuries AD	AD 201 - AD 500

Table 5.6: The chronological periods selected for the amphora analysis.

world, means this data should be approached with caution.³⁰ To complement the probable contents of each amphora form, the volume in litres of each vessel was also included where known.³¹ Volume provides a more accurate indication of the quantity in which each product type was moving, as opposed to simply counting the number of vessels transporting them.

Where possible, the dating of each sherd was taken from the assemblage publication. Unfortunately, a consequence of using urban assemblages was that sealed contexts were rare, resulting in many of the recovered fragments originating from disturbed contexts as residual material.³² This meant that stratigraphic dating was often not possible, and established chronologies for each vessel form originating from their typologies were often used instead. Where dating for an amphora vessel form was absent from a publication, the estimated date range listed on the University of Southampton Archaeology Data Service was applied.³³ To enable comparison, the various vessel forms were placed within broad chronological periods reflecting their most prominent era of production and circulation. The longevity of some amphora forms, coupled with uncertainty over the start and end dates of their production, meant that it was necessary to maintain broad dates for these periods, which are defined in Table 5.6. Each vessel was assigned the period which encompassed either the entirety or majority of its production lifespan.³⁴ While it is possible that some vessel forms might have seen production

³⁰ On amphora reuse more generally, see Abdelhamid (2013); Brughmans and Pecci (2020); Pecci et al. (2017).

³¹ The volume displayed in the database is an average volume for each amphora form. The measurements were taken from Vidal and Corredor (2018). No estimated capacities were found for the Ovoidale Adriatichi and Anfora con Collo ad Imbuto forms, however, they are often compared to Dressel 6Bs in both size and shape (Carre and Pesavento Mattioli (2003), 460; Gaddi and Maggi (2017), 308; Mazzocchin (2009)). Consequently, the volume of the Dressel 6B has been used as an estimate of their capacity. The volume of the Grado 1 form came from Auriemma and Pesavento Mattioli (2009), 275.

³² This is due to the constant cycle of construction and destruction in the urban environment, resulting in earlier layers being intruded upon by later intervention, and their material becoming mixed. For example, in the MM3 excavations in Milan, most Roman era material was recovered from post-Roman contexts (Bruno and Bocchio (1991), 293-4).

³³ https://archaeologydataservice.ac.uk/archives/view/amphora_ahrb_2005/info_intro.cfm (Accessed 26/11/19).

³⁴ The Augustan Period was included with the first-second centuries AD due to the overlap in vessel forms between the late first century BC and first century AD.

outside these parameters, these are exceptional cases. While greater chronological resolution was available for some assemblages, such level of detail was not possible to maintain across a study of this size where secure stratigraphic dating was often lacking. Consequently, although there is likely to be some margin of error on a site-by-site basis, although overall patterns are robust.³⁵

While many of the amphora assemblages contained data for stamps and *tituli picti*, the *Centro para el Estudio de la Interdependencia Provincial en la Antigüedad Clásica* (CEIPAC) amphora database contained a much broader array of material from the region.³⁶ Consequently, it was decided to use the material from the CEIPAC database, rather than site publications, for the epigraphic analysis. A body of 1465 stamps was compiled from the database for analysis with 626 individual stamps attested. To ensure a rigorous level of analysis, only sites that returned more than five stamps were included.

5.2.2 Finewares

In a similar manner to the amphora data, the fineware vessel form assigned by the publication was used for each fragment where possible. However, some excavations were conducted before updated typologies were available. For example, the MM3 excavations in Milan mainly utilise Goudineau's and Pucci's typologies, rather than the more recent *Conspectus* series that has become the dominant typology used to identify Northern Italic sigillata.³⁷ Within the database, the most commonly used and up-to-date classification for a vessel form was adopted in order to reduce possible confusion and ease comparison between the assemblages. Concordances between typologies are listed within the *Conspectus Series*.³⁸ Finally, fragments for which the vessel form was unknown, but whose area of production could be traced through fabric analysis were grouped together by provenance. Unidentified fragments and vessels with no known typology that lacked a secure provenance were grouped as Unknown. The different fineware styles present (Terra Sigillata, Sigillata Tardopadana, Eastern Sigillata, ARS, and Sigillata Medio-Adriatic), were recorded for each fragment. Finally, the fabric group for each sherd of Eastern Sigillata and ARS were also entered. Sub-fabric types (e.g. D2) were rarely recorded and are missing for most assemblages published

³⁵ For example, there are rare cases of Dressel 6Bs being produced in the third century AD, when the overwhelming majority of production took place during the first-second centuries AD (Cipriano (2009), 175).

³⁶ http://ceipac.ub.edu/index_en.html (Accessed 26/11/19). Access to the database can be requested through the website.

³⁷ The *Conspectus* typology (Ettlinger et al. (1990)) was created from the analysis of the terra sigillata recovered from the closely dated stratigraphy present at Magdalensburg, Austria. See Jorio (1991) for Milan.

³⁸ Ettlinger et al. (1990), 190-97.

Long Date	Short Date	Chronology
	Augustan Period	27 BC - AD 14
First-Second Centuries AD	First Century AD	AD 15 - AD 100
	Second Century AD	AD 101 - AD 200
	Third Century AD	AD 201 - AD 300
Third-Fifth Centuries AD	Fourth Century AD	AD 301 - AD 400
	Fifth Century AD	AD 401 - AD 500

Table 5.7: The chronological periods selected for the fineware analysis.

before the turn of the century. Consequently, they are not included here.

Each fragment was assigned a geographical provenance for its probable production area. The first was ‘Central Italic’, for finewares produced in Arezzo or other Central Italian sites. In approximately half of the sites discussed, the publications did not differentiate between Arretine and Central Italic provenances for sigillata from the rest of Italy. As a result, both are referred to having a Central Italic origin, even if a more accurate provenance was available. However, the more specific Arretine and Central Italic provenances were still recorded where available in a separate column, to allow for additional analysis. The second provenance was ‘Northern Italic’, which encompassed all vessels produced in Northern Italy. The third was a ‘Gallic’ provenance. While most publications distinguished between sigillata produced in Southern and Central Gaul, this distinction was not present for all sites.³⁹ Due to this and the low quantity of Gallic sigillata across much of the study area, it was decided to use a generic ‘Gallic’ origin for this tableware so as not to obscure overarching patterns in the data. However, the more specific Southern and Central Gallic provenances were still recorded where available in a separate column, to allow for additional analysis. The fourth provenance was ‘Eastern’, containing vessels originating from the Eastern Mediterranean. The fifth was ‘African’ for vessels produced in North Africa, with the sixth and final provenance being ‘Adriatic’ for vessels being produced along the Central Adriatic coast. Due to the overlap in forms between Italian and Gallic Sigillata, fineware provenance is often determined by fabric in the absence of stamp.⁴⁰ This means some provenances may be more accurate than others, depending on the quality and understanding of the fabric available.

When it came to dating sherds, the nature of fineware production meant that a far greater chronological resolution was available for the data in comparison to the amphorae. For most fineware styles, the recorded typologies are well-established

³⁹ Where a distinction between Southern and Central Gallic production was not available, the provenance was simply listed as Gallic.

⁴⁰ Lewit (2015), 228.

and allow a fine level of chronological detail.⁴¹ With the addition of a potter's stamp, it was often possible to trace a sherd's production to within a decade or so. This meant that, in many cases, changes in vessel forms, provenance, and distribution were able to be analysed on a century-by-century basis, as opposed to broad periods. However, some sites, such as Turin, only included broad dating in their studies, and some vessel forms, such as the *Conspectus 3* or *Dragendorff 24/25*, had a longevity of production lasting several centuries. Furthermore, the absence of an identifiable stamp can widen the possible chronology of some sherds to one or two centuries. For the later Northern Italic *Terra Sigillata* and *Sigillata Medio-Adriatica*, the chronology available was also much broader.⁴² This often prevented them from being used in the century-by-century analysis. The solution was to analyse the data using short and long chronologies. The short chronological analysis uses fineware data that could be dated to within a century of production, while the long chronological analysis utilises all data by assigning the sherds to broad chronological periods in the same manner as the amphora data.⁴³ The individual periods used in the short and long chronologies can be seen in Table 5.7. Where possible, the dating of each sherd was taken from the assemblage publication. However, some fineware typologies, such the Hayes series, have been refined since publication, which meant chronologies present in older assemblages were no longer up-to-date.⁴⁴ Where necessary, the dating was adjusted to take into account the updated chronology. If there was overlap between centuries in a fragment's dating, the fragment was assigned to the century containing the majority of its chronology. Finally, where dating was absent for fineware sherds (for example finds from residual contexts), but their forms were known, the vessels were assigned a date using the relevant typology.⁴⁵

As opposed to the amphora data, which used the CEIPAC database for its epigraphic analysis, stamp data for finewares were taken directly from the assemblage publications. Of the 8218 sherds of fineware present in the database, 735 possessed legible stamps. Given the fragmentary nature of most stamps, a workshop was assigned to each one to allow ease of comparison.⁴⁶ From the 735 stamps, 310 individual workshops were attested. Both the original stamp and the

⁴¹ Bonifay (2004); Dragendorff (1895); Ettliger et al. (1990); Hayes (1972); (2008).

⁴² Brecciaroli Taborelli (1978), 1-38; Zabehlicky-Scheffenecker (1992); Zabehlicky Scheffenecker and Sauer (2000).

⁴³ In a similar manner to the amphora data, the Augustan period was included as part of the first-second centuries AD in the long chronological analysis.

⁴⁴ See Bonifay (2004); Hayes (1972); (2005); (2008).

⁴⁵ For example, the publication of the sigillata from the MM3 excavations in Milan did not provide a chronology for most of its sigillata forms (Jorio (1991)).

⁴⁶ Stamps were assigned a workshop based on identification from the second edition of the *Corpus Vasorum Arretinorum* (Oxé et al. (2000)).

workshop it was assigned to were recorded for each entry. To ensure a rigorous level of analysis, only sites that returned more than five stamps were included.

5.2.3 Decorative Stone

With stone and marble, the lithotype assigned by the publication was used to identify each fragment of veneer. The most common nomenclature (such as *gi-allo antico*, *africano*, Proconnesian etc.) was used to define the stone or marble present, with a list of concordances found via the Oxford Corsi Collection of Decorative Stone.⁴⁷ While advances in archaeometric analyses have allowed the development of new methods for identifying the provenance of stone and marble, some studies predate such progress.⁴⁸ As a result, the largest component of each dataset was often white marble (of varying coarseness) with an unidentified provenance (see Appendix C). The colour of each lithotype (either white, grey, or polychrome) was also recorded.

Each fragment within the database was assigned a point of provenance. While specific quarry sites are known for most stone quarried, broad provenances were used to highlight overarching patterns in the data.⁴⁹ Stone and marble extracted from Egypt and North Africa was recorded as coming from ‘Egypt and North Africa’.⁵⁰ Stone and marble quarried on mainland Turkey or in the Sea of Marmara was referred to as having come from ‘Asia Minor’. Marble from France was referred to as having a ‘Gallic’ origin. Stone and marble extracted from the Aegean islands and Greek mainland was referred to as having originated from ‘Greece and the Aegean’. Stone and marble extracted from sites within the Alps was referred to as having an ‘Alpine’ provenance. Finally, stone and marble extracted from south of the Apennines in Italy (including in the Apuan Alps) was given a ‘Central Italian’ provenance. Where possible, the provenance of each fragment was taken from the assemblage publication, however, except in the case of *greco scritto*. While previously thought to have been sourced from North Africa, recent research has shown that most *greco scritto* quarried in antiquity probably originated from Asia Minor.⁵¹

When it came to dating the material within the stone and marble assemblages, in some cases the chronology was highly specific. For many structures, especially

⁴⁷ <http://www.oum.ox.ac.uk/corsi/> (Accessed 01/01/2022).

⁴⁸ Lazzarini (2019).

⁴⁹ A comprehensive list of known quarries for each stone and marble type can be found via http://www.romaneeconomy.ox.ac.uk/databases/stone_quarries_database/ (Accessed 01/01/2022).

⁵⁰ The two provenances were grouped due to the minimal quantities of Egyptian stone in the dataset.

⁵¹ Attanasio et al. (2012). Previously, *greco scritto* was thought to have originated from quarries at Cap de Garde in Algeria. Isotopic and EPR analysis revealed that the quarries at Hasançavuslar, near Ephesus, were in fact the main source during the Roman period.

public buildings, the construction date could be narrowed down to within a few decades, if not greater accuracy. However, in other cases, chronological data was missing, or the material was predominantly from residual contexts. For example, the publication of the MM3 excavation's assemblage of Roman marble wall revetment and floor panelling did not include a chronological element and its exact origin could not be pinpointed.⁵² Given that most secure contexts providing stone and marble veneer could be dated to between the first century BC and the first century AD, it was decided to analyse the stone and marble assemblages as a single chronological dataset. This would also remove the need to account for missing chronology from residual contexts.

5.3 The Quantitative Analysis

Once the data had been standardised and entered into the spreadsheets, they were ready to be analysed. RStudio was the statistical software used to explore the assemblages and the code used to run the analysis can be found within Appendix B. The number of sherds/fragments of each vessel form/lithotype can be viewed in Appendix C, divided by site and period.

For the amphora and fineware datasets, the sherds were initially divided by period. The total number of each vessel form, separated by provenance, were displayed. The provenances of the total amphora and finewares datasets for each period were graphed as percentages. The percentages of each provenance per period per site were then calculated and displayed, with sherds without a known provenance or period being excluded from the analysis. The percentages for each provenance by period for each site were then placed in a table. The data in this table were used to explore the presence of any clusters amongst the sites, using the UPGMA algorithm (Unweighted Pair Group Method with Arithmetic mean). This was used to calculate the pairwise distance between each site assemblage based on the provenance of the vessels within it.⁵³ This created a hierarchical cluster of the sample based on the similarity of each assemblage, which was then plotted as a dendrogram. This analysis was repeated for each period. The data used for the hierarchical clustering can be found in Appendix B.

For the decorative stone dataset, the total number of each lithotype, separated by provenance, was displayed. The provenances of the total decorative stone dataset was graphed as percentages. This was repeated separately for white

⁵² Terracina (1991). The assemblages from Altinum (Minato (2018)), and Alessandria and Tortona (Gomez Serito (2007)) also lacked a chronological element in their publication.

⁵³ Pairwise distance measures the separation between values of a dataset (in this case the percentage of each provenance).

$$D = 1 - \frac{\sum n(n-1)}{N(N-1)}$$

Simpson's Diversity Index

$$C_H = \frac{2 \sum_{i=1}^S x_i y_i}{\left(\frac{\sum_{i=1}^S x_i^2}{X^2} + \frac{\sum_{i=1}^S y_i^2}{Y^2} \right) XY}$$

Morisita-Horn Overlap Coefficient

and polychrome stone. The percentage of each provenance per site was then calculated and displayed, with fragments without a known provenance or period being excluded from the analysis. The percentages for each provenance for each site were then placed in a table. The data in this table was used to explore the presence of any clusters amongst the sites, using the UPGMA algorithm. This was used to calculate the pairwise distance between each site assemblage based on the provenance of the lithotypes within it. This created a hierarchical cluster of the sample based on the similarity of each assemblage, which was then plotted as a dendrogram. The data used for the hierarchical clustering can be found in Appendix B.

The diversity of vessels and lithotypes at each site was examined using Simpson's Diversity Index (see equation above).⁵⁴ A presence-absence table was created, containing the forms and quantities of vessels present at each site. Unidentified sherds and lithotypes were excluded from this analysis and NULL values were set to read as zero. The results for each site were recorded as a number between 0 and 1, where 1 represents infinite diversity, and 0 represents no diversity. The results were then plotted as a bar plot. To complement Simpson's Index, the vessels and lithotypes of each assemblage were also examined using the Morisita-Horn Overlap Coefficient (see equation above).⁵⁵ The coefficient was able to take into account the frequency of certain vessels/lithotypes amongst the assemblages, in addition to the presence and absence of certain types. The results for each site were recorded as a number between 0 and 1, where 1 represents complete similarity, and 0 represents no similarity. These results were then converted into a distance matrix (where 0 represented complete overlap be-

⁵⁴ Here, n represents the number of fragments of a particular vessel form, and N represents the total number of fragments for all vessel forms.

⁵⁵ Here, x_i is the number of times fragment/lithotype i is represented in the total X from one sample, while y_i is the number of times fragment/lithotype i is represented in the total Y from another sample. S is the number of unique fragments/lithotypes in the total dataset.

tween two assemblages and 1 represented no overlap between two assemblages), the results of which were plotted as a dendrogram. The stamp datasets for the amphora and fineware data were also analysed using the Morisita-Horn Overlap Coefficient. The stamp results from the Morisita-Horn Overlap Coefficient were also converted into a distance matrix and plotted as a dendrogram.

5.4 Conclusions

The dataset of amphorae, finewares, and stone assembled here forms a complex, yet powerful, tool to analyse inland trade in Northern Italy. Preparing the assemblages for analysis, published at different times and to different standards, was a difficult task. Compromises have been made and, in some cases, the data will be analysed at a lower level of geographical and chronological resolution than that offered by its original publication. Despite these necessary limitations, and with careful attention to its strengths and flaws, the methodology outlined above will allow a far greater scope of quantified analysis to be undertaken than has previously been achieved in Northern Italy. The first materials analysed are amphorae, the largest of the three datasets with the most extensive publication across the region.

Chapter 6

Amphorae

Amphorae have long been used as proxies for the study of long-distance trade, primarily in foodstuffs and other consumables.¹ Amphorae carried a wide range of goods, most notably, wine, oil, and fish products, but also fruits, nuts, and alum, amongst others.² Their widespread distribution across the Roman world and high rate of survival in the archaeological record has made them an obvious choice for tracking patterns in trade and connections between producers and consumers. Amphora-based studies have often revealed interesting patterns and trends in the circulation of goods at sub-regional, regional, and supra-regional level, with some of the best prior studies on their inland distribution undertaken in Britain, France, and Germany.³ These locations had military connections, either through their garrisons or the supply network, which may, at times, have influenced the pattern of trade within them. In a similar vein, studies in Italy have mainly focused on the Tiber valley, looking at the river both north and south of Rome.⁴ However, the presence of the capital on the river will undoubtedly have distorted trade flows, making the Tiber valley a unique economic environment. Northern Italy's economy was not shaped by military demand or by the pull of Rome to the same extent as the locations above, and the region offers a unique perspective on the inland trade of amphora-borne goods.

Within Northern Italy, prior studies of amphora-borne trade have tended to focus on the distribution of individual vessel types or trade flows at individual sites. The amphora forms *Anfora con Collo ad Imbuto*, Dressel 6A, Dressel 6B, and Lamboglia 2, have seen sustained scholarly interest, being amongst the

¹ As one of the most heavily studied and typologised ceramic categories from the Roman world, amphorae are one of the most commonly used proxies for the analysis of long-distance trade, at times at the expense of other data. For a discussion on the role of proxies in analysing Roman trade; see Scheidel (2009), with Wilson's (2009a) response; Wilson (2009b); (2014).

² See Peña (2007b), Chapter 5 for examples of more varied contents.

³ For example, Carreras (1994a); Franconi (2014), 189-218; Laubenheimer (2001).

⁴ De Sena (2005); Mattingly and Aldrete (2000); McCallum (2004).

most frequently recovered vessels in the region.⁵ Uniformly produced along the Adriatic littoral, their diffusion and chronology are well understood, but for the most part, studies have been unquantified. Furthermore, the spread and quantity of amphorae from other provenances, such as the Camulodunum 184, Dressel 2-4, Dressel 7-11, remains relatively unknown.⁶ Assemblages at individual urban sites have seen detailed quantitative analysis but their findings are rarely integrated into wider discussions on trade or compared with other sites.⁷ A wealth of data exists in Northern Italy that has the potential to answer complex questions on inland amphora-borne trade, but it has yet to be combined and studied at a regional level.

This chapter uses the assembled amphora data from urban sites to analyse trade patterns in Northern Italy between the first century BC and the fifth century AD. The results from the analysis are presented, outlining where the majority of amphora imports originated on a site-by-site basis. Areas of the region that exhibited high diversity in their amphora forms and imports are highlighted, and reasons offered as to why this might have been the case. The resulting patterns are then situated within a chronological and geographical framework, allowing a picture of how amphora-borne trade evolved across Northern Italy to emerge. A final discussion situates the results within wider debates on the mechanics of inland economies during the Roman period. The locations of sites mentioned within this chapter can be viewed in Figure 6.1.

6.1 Data and Deposits

Amphorae form the principal surviving long-distance transport container from the Roman period and are found in significant quantities across the Roman world. While providing a large corpus of evidence to work with, amphorae are a complex dataset for a number of reasons. First and foremost, amphorae represent only one possible form of container circulating during the Roman era. Other containers, such as barrels and skins, only survive under certain preservation conditions and are found far less frequently than their ceramic counterparts.⁸ Although the

⁵ See Cipriano (2009); Cipriano and Mazzocchin (2012); Mazzocchin (2009). Bruno (2005a) gives a brief overview of the regional chronology of the most common amphora forms found within Northern Italy.

⁶ There have been limited attempts to look at the distribution of other amphorae, such as the Dressel 7-11 or the Richborough 527, but the coverage is so disparate (often limited to the jurisdiction of a single *soprintendenza*) that it is difficult to form a regional picture. For example, Gonzalez Vilches et al. (1998); Modrzewska and Pianetti (1994); Quiri and Spagnolo Garzoli (2015).

⁷ For example, Gabucci and Quiri (2008); Spagnolo Garzoli et al. (2007); (2008).

⁸ The majority of surviving examples come from France, Germany, and Britain (Marlière (2001)).

waterlogged contexts of Northern Italy should provide optimum preservation conditions, surviving examples of such containers have yet to be recovered from the region.⁹ There is also the uncertainty surrounding what amphorae may have been carrying and where they may have originated. Across the period under study, Northern Italy's amphorae originated from six different zones of production: the Adriatic coast, the Eastern Mediterranean, Gaul, the Iberian Peninsula, North Africa, and the Tyrrhenian coast. Studies using amphorae as a proxy for trade work on the assumption that their provenance was from the area where the vessel was produced. However, over the past twenty years, evidence for the reuse and recycling of amphorae has increased.¹⁰ A Dressel 6A wine amphora manufactured on the Adriatic coast may not necessarily have travelled from there when it entered Northern Italy, nor may it have been carrying wine.¹¹ Unfortunately, without specialist testing such as residue analysis, it is often impossible to tell what amphorae were carrying and where they originated from before their entry into the archaeological record.¹² As such, there is often a degree of assumption in the determination of their provenance and contents.

Within Northern Italy, amphorae have been recovered from a variety of urban contexts. Some are found where they were discarded, while others originate from disturbed contexts, recorded as residual finds in excavation reports. In most cases, the largest quantities of amphorae, often surviving as complete or near-complete vessels, have been recovered from reclamation deposits (see Figure 6.2.). In these deposits, recycled whole amphorae were placed to stabilise, aerate, or drain damp and unstable soils during the Roman period.¹³ The contexts of reclamation deposits vary, ranging from domestic townhouses to large-scale infrastructure projects.¹⁴ Hundreds of vessels might be used even in small projects, with the largest, such as a deposit found beneath the via Aemilia near Piacenza,

⁹ This may be due to similar reasons for the lack of inland wrecks recovered from the area (see Section 3.1.4). Barrels are, however, attested to in the region by Strabo and funerary stele recovered in Piedmont (Strabo, 5.1.12. Tchernia (1986), 286-88.). The closest example was a barrel recovered from the Grado wreck containing recycled glass (Giacobelli (1997)). For a history of containerisation in the Mediterranean, see Bevan (2014).

¹⁰ Abdelhamid (2013); Brughmans and Pecci (2020); Pecci et al. (2017); Peña (2007b). Indeed, the majority of amphorae in this study were recovered in contexts where they had been recycled.

¹¹ For example, Mazzocchin and Wilkins (2013), have found examples of Dressel 6A wine amphorae being reused to carry fish products.

¹² Maritan et al. (2019); Pecci et al. (2017).

¹³ Reclamation contexts are found across the Roman world, the most notable being at the Castro Pretorio in Rome, which gave rise to Dressel's famous typology (Dressel (1879)). The majority of discoveries have come from Northern Italy and Southern France, where high water tables and marshy ground saw the need for more extensive foundation work. For a discussion on the mechanisms behind reclamation deposits and their distribution within Northern Italy, see Antico Gallina (2011); (2014); Calzolari (1995); Cipriano and Mazzocchin (1998). For examples of reclamation deposits elsewhere within the Western Empire, see Antico Gallina (2011), 193-96; Laubenheimer (1991); Laubenheimer et al. (1992).

¹⁴ Cipriano and Mazzocchin (1998); Pesavento Mattioli (1998).

containing tens of thousands of vessels.¹⁵ Larger amphorae were favoured for this task, particularly the Adriatic Lamboglia 2, Dressel 6A, and Dressel 6B forms, and it is possible these vessel types are consequently overrepresented within the dataset when compared to smaller vessel forms. However, upon comparison with other assemblages, such as those from Brescia, Cividate Camuno, and Industria, which do not include reclamation deposits, overall trends in provenance and vessel forms are maintained (see below).¹⁶

The high number of reclamation deposits across the Po-Veneto plain has resulted in a large survival bias towards vessels from the early Imperial period. The majority of reclamation deposits were created during the late first century BC and first century AD, at a time when large-scale landscape intervention was being undertaken across the Po-Veneto plain. The deliberate burial of these amphorae below occupation levels has helped to ensure their survival in the archaeological record, providing a much wider dataset for examination. As a consequence, amphorae from the third-fifth centuries appear in much lower quantities and the best-quality data comes from between the late first century BC to the late second century AD.

6.2 Analysis

Using the parameters outlined in Chapter 5, a total of twenty-four assemblages from inland urban centres across Northern Italy were compiled for analysis. Six port assemblages were also examined to provide points of contrast: four from the Adriatic seaboard – Altinum, Aquileia, Ariminum, and Ravenna, and two from the Ligurian seaboard – Luna and Porto Maurizio. All sites selected for analysis can be seen in Table 6.1 and are mapped geographically in Figure 6.3. The number of sherds in the dataset totalled 19,765. Of these, 2800 belonged to the Late Republic, 13,048 to the first-second centuries AD, and 3034 to the third-fifth centuries AD (see Figure 6.4). The total number of sherds by site per period can be found in Appendix C.

6.3 Results

The results of the analysis were uneven across the three chronological periods. The poor data quality from the Late Republic and third-fifth centuries AD ham-

¹⁵ Marini Calvini (1999), 190-91.

¹⁶ The Lamboglia 2, Dressel 6A, and Dressel 6B remain the most common vessel forms in their respective periods and the Adriatic continues to be the dominant provenance for amphora imports across sites both with and without reclamation deposits.

Site	N. of Fragments	Publication
Acqui Terme	847	Bruno (1998); Secchi (2017)
Alba	943	Bruno (1997)
Altinum	306	Cipolato (2018); Pizzolato (2018a); (2018b) Auriemma and Degrassi (2017); Battistin (2017); Bonivento (2017);
Aquileia	3160	Bonivento and Vecchiet (2017a); (2017b); (2017c); Gaddi (2017); Gaddi and Maggi (2017)
Ariminum	107	Angelini (2018); Biondani (2005a)
Augusta Bagiennorum	271	Quiri (2014)
Bologna	239	Baldoni (1986)
Brescia	1056	Bruno and Bocchio (1999) Dobrevá (2013);
Calvatone	269	Masseroli (1997); Volonte (1996)
Cividate Camuno	129	Bocchio (2004) Bruno (2005b);
Como	445	Butti (2016); Facchini and Leotta (2005)
Cremona	531	Acari (1996)
Este	106	Michelini and Mazzocchin (1998)
Forlì	1012	Tempesta (2013)
Industria	80	Zanda (2011)
Ivrea	1041	Gabucci and Quiri (2008); Brecciaroli Taborelli (1987b)
Libarna	82	Bruno (1998)
Luna	605	Bruno (1998)
Milan	1755	Bruno and Bocchio (1991)
Modena	857	Mongardi (2014)
Novara	551	Spagnolo Garzoli et al. (2007); Quiri and Spagnolo Garzoli (2015)
Oderzo	1094	Cipriano and Ferrarini (2001) Cipriano et al. (1991);
Padua	1516	Cipriano and Mazzocchin (1998); Pesavento Mattioli (1992)
Porto Maurizio	260	Parodi (2013)
Ravenna	65	Tempesta (2018)
Reggio Emilia	38	Covizzi (1996)
Trento	775	Maurina (1995)
Vercelli	116	Brecciaroli Taborelli (1987a) Biondani (2008);
Verona	773	Bruno (2008); Buchi (1973); Pavoni (2008)
Vicenza	733	Mazzocchin (2011)

Table 6.1: Amphora assemblages analysed in Chapter 6.

pered the quantitative analysis, with few underlying patterns coming to light. However, several interesting observations could still be made from the data. In contrast, several clear patterns could be initially discerned within the first-second centuries AD data with further underlying trends identified via quantitative analysis. A full discussion of the results can be found in Sections 6.4-6.

6.3.1 The Late Republic

Out of the thirty sites within the amphora dataset, eleven returned more than thirty sherds from the Late Republic. During this period, amphorae originated from five different zones of production: the Adriatic, the Eastern Mediterranean, the Iberian Peninsula, North Africa, and the Tyrrhenian coast (see Figures 6.5 and 6.6). Adriatic vessels made up the overwhelming majority of imports across the region, accounting for 71.2% of the Late Republican dataset. The Tyrrhenian coast was the next most common provenance, accounting for 25.5%. Amphorae from the Eastern Mediterranean, the Iberian Peninsula, and North Africa did not appear in quantities above 2%.

Thirteen individual vessel forms were attested in Northern Italy during the Late Republic (see Figures 6.7 to 6.11). Across the assemblages, the majority of Adriatic vessels were of the Lamboglia 2 form, a wine amphora that predominantly circulated during the mid-late first century BC (see Figure 6.12).¹⁷ Production seems to have mainly taken place on the western coast of Italy in the area of Picenum, with some production also documented in Northern Italy near Modena and Aquileia (see Figure 6.13).¹⁸ Other Adriatic vessels circulating within the study area at this time also included the Brindisian, late form Greco-Italic, and Ovoidali Adriatiche forms, all to a much lesser extent than the Lamboglia 2 (see Figures 6.14, 6.15, and 6.16).¹⁹ Each of these types was also produced along the western Italian coast, with both the Brindisian and Greco-Italic forms probably carrying wine, and the Ovoidali Adriatiche oil. Both the Brindisian and Greco-Italic forms are chronologically earlier than the Lamboglia 2, which seems to have replaced these vessel types as the dominant wine container

¹⁷ For details of the Lamboglia 2, see: https://archaeologydataservice.ac.uk/archives/view/amphora_ahrb_2005/details.cfm?id=229 (Accessed 16/12/2021); Cipriano and Mazzocchin (2019); Van Limbergen (2018), 206-07.

¹⁸ Carre et al. (2014), 419-22. A Dalmatian origin has been argued for the Lamboglia 2 in the past (see Lindhagen (2009)), but this is no longer widely accepted.

¹⁹ For details of Brindisian amphorae, see: https://archaeologydataservice.ac.uk/archives/view/amphora_ahrb_2005/details.cfm?id=51 (Accessed 16/12/2021). For details of Greco-Italic amphorae, see: https://archaeologydataservice.ac.uk/archives/view/amphora_ahrb_2005/details.cfm?id=141 (Accessed 16/12/2021). For information on the amphora Ovoidali Adriatiche, see: Carre and Pesavento Mattioli (2003), 454-60; Carre et al. (2014), 419-22. The Ovoidali Adriatiche form remains one of the least understood forms from this region and period.

circulating in the Adriatic during the early first century BC. Tyrrhenian imports are represented by the Dressel 1 amphora, a wine vessel mainly produced in Campania and Tuscany, alongside Greco-Italic amphorae produced on the Tyrrhenian coast (see Figure 6.17).²⁰ Imports from the Eastern Mediterranean are predominantly early forms of Rhodian amphorae. Mirroring the Tyrrhenian imports, they mainly occur at sites in the east of the study area, namely Calvatone, Cremona, and Padua. No Iberian vessel forms were successfully identified, their provenance based on fabric analysis. North African imports are mainly represented by Late Punic amphorae, with single examples of the forms Dressel 18, Van der Werff 2 and Van der Werff 3.

Wine seems to have been the most prominent amphora-borne product during the Late Republic, with 95.8% of the vessels recovered from the period associated with this commodity (see Figure 6.18). Oil comes a distant second, carried by just 4% of the vessels. Finally, a single example of Dressel 18 from Vicenza offers some limited evidence for trade in fish products. This pattern was reinforced when the vessels were measured by volume (see Figure 6.19). There seems to be little variation in the percentage ratio of products across the assemblages, with hierarchical clustering failing to reveal any deeper pattern to their distribution. Wine formed the most prominent commodity in each location and oil was present at sites in both the upper valley and the coastal hinterland.

When sites in the Late Republican dataset were hierarchically clustered using the UPGMA algorithm based on the provenance of their assemblages, a single broad geographic cluster was identified (see Figure 6.20 and 6.21). This contained eight sites, the assemblages of which comprised between 81.2% and 94.1% amphorae of an Adriatic provenance. The only inland site not to join this cluster was Ivrea in the western Po valley, which placed independently. The composition of Ivrea's assemblage was very different from other Late Republican sites. Only 64.8% of its assemblage derived from an Adriatic point of origin, and it contained the highest quantity of Tyrrhenian amphorae out of the Late Republican dataset (29.9% of Ivrea's assemblage). Ivrea was also the only site to contain vessels of Iberian provenance. These factors served to set it apart from the rest of the sites, which were predominantly located in the central and eastern Po valley, alongside the coastal plain. The addition of assemblages from the Adriatic and Ligurian ports to the analysis did not significantly change the clusters. Aquileia's assemblage was comprised almost entirely of Adriatic vessels (99.4%), causing it to join the main cluster (see Figure 6.22). Luna's assemblage was predominantly formed

²⁰ For details of the Dressel 1, see: https://archaeologydataservice.ac.uk/archives/view/amp_hora_ahrb_2005/details.cfm?id=324 (Accessed 16/12/2021). Most reports did not differentiate between the identified subclasses of the Dressel 1 form.

of Tyrrhenian amphorae (91.4%), causing it to place independently with a high distance between it and assemblages within the Po-Veneto region (see Figure 6.23).

The lack of variety in the provenance of Late Republican assemblages was also mirrored by the limited diversity of the vessels contained within them. When measured with Simpson's Index, most sites scored below 0.5, suggesting a greater level of uniformity than diversity amongst the assemblages (see Figure 6.24). This was unsurprising given the overwhelming dominance of a single vessel form across the region. Two sites bucked this trend, Ivrea and Verona, both of which returned scores of above 0.5, suggesting more diversity than uniformity in their assemblages. This pattern was repeated when the Late Republic assemblages were analysed using the Morisita-Horn Overlap Coefficient (see Figure 6.25). Most sites clustered closely together and scored below 0.1, suggesting extremely high levels of overlap and the abundance of certain vessel types amongst them. Both Ivrea and Verona showed less similarity in the makeup of their assemblages.

The similarity of Late Republican amphora stamps between sites within the CEIPAC database was compared using the Morisita-Horn Overlap Coefficient. The majority of vessels from Northern Italy within the CEIPAC amphora had an Adriatic provenance, with the Lamboglia 2 the most prominent vessel type (see Figure 6.26). When the results were displayed in a dendrogram, no geographic pattern could be observed in the data (see Figure 6.27). All assemblages had a distance of over 0.75 from others in the dataset, and clustering was limited, suggesting a low level of stamp overlap between sites.

In summary, the picture of amphora-borne trade that emerges during the Late Republic is one dominated by goods originating from the Adriatic. Adriatic wine, first carried in Greco-Italic and Brindisian containers, before being replaced by the Lamboglia 2, was the most common amphora-borne cargo. Oil seems to have taken up only a small share of the market, carried solely by the Ovoidali Adriatiche type. The dominance of Adriatic production and the limited number of vessel forms circulating during this period resulted in greater uniformity, rather than diversity, amongst Late Republican amphora assemblages. Other regions also contributed to Northern Italy's supply, but other than the Tyrrhenian coast, these seem to have been of minor importance. Even then, Tyrrhenian amphorae only appeared in significant quantities in the west of the valley, close to the Ligurian ports.²¹

²¹ See Bruno (1998) for additional discussion on Tyrrhenian imports to the western Po valley.

6.3.2 The First-Second Centuries AD

All thirty sites within the amphora dataset returned more than thirty sherds from the first-second centuries AD. Moving into this period, a more complex picture of amphora-borne trade begins to emerge. During the first-second centuries AD, amphorae originated from five different zones of production: the Adriatic, the Eastern Mediterranean, Gaul, the Iberian Peninsula, North Africa, and the Tyrrhenian coast (see Figures 6.28 and 6.29). The Adriatic continued to dominate provenances, with Adriatic vessels forming 66.28% of the total assemblage from the first-second centuries AD. Eastern vessels came second with approximately 19.26%, Iberian imports formed 8.72%, Gallic 2.33%, Tyrrhenian 2.18%, and North African 1.2%.

During the first-second centuries AD, sixty-four individual vessel forms were attested in Northern Italy (see Figures 6.30 to 6.36). The most common amphora forms originating from the Adriatic during this period were Dressel 6A wine and Dressel 6B oil amphorae (see Figures 6.37 and 6.38).²² Together, they made up approximately 43.66% of the total sherds dating to the first-second centuries AD. The forms had widespread diffusion across the region and with the exception of Brescia, either the Dressel 6A or 6B were the most numerous vessels recovered from each site (see Appendix C). The third most common vessel recovered was the Flat-Bottomed Italic form, which made up 7.29% of the first-second centuries AD assemblage (see Figure 6.39).²³ This vessel began circulation during the early second century AD, before ending in the late second to early third century. The spread of locally produced Flat-Bottomed Italic amphora seems to have been limited to the coastal hinterland, with the form seeing a minimal distribution inland. It is, however, recovered in comparatively large quantities at port sites on the Adriatic coast, particularly Aquileia. The final significant amphora type from the Adriatic area was the Anfora con Collo ad Imbuto or ‘funnel-necked amphora’ (see Figure 6.40).²⁴ This formed 4.63% of the first-second centuries AD assemblage and was used to carry oil. The Anfora con Collo ad Imbuto shares many typological similarities with the Dressel 6B form, although seems to have had greater longevity.²⁵

²² For information on the Dressel 6A, see: https://archaeologydataservice.ac.uk/archives/view/amphora_ahrb.2005/details.cfm?id=113 (Accessed 16/12/2021). For information on the Dressel 6B, see: https://archaeologydataservice.ac.uk/archives/view/amphora_ahrb.2005/details.cfm?id=114 (Accessed 16/12/2021). See also: Cipriano (2009); Cipriano and Mazzocchin (2012); (2018); (2019).

²³ For information on Flat-Bottomed Italic amphorae, see: Aldini (1978); (1989); (1995); Panella (2002).

²⁴ For information on the Anfora con Collo ad Imbuto, see: Cipriano and Ferrarini (2001); Cipriano and Mazzocchin (2012); Mazzocchin (2009).

²⁵ Mazzocchin (2009), 196-97. While the majority of Anfore con Collo ad Imbuto date to the

Dressel 2-4 wine amphorae proved some of the most common vessels across the assemblage, making up 10.96% of the total assemblage (see Figure 6.41).²⁶ When broken down, 4.3% had an Eastern provenance, 2.99% an Adriatic provenance, 1.84% an Iberian provenance, 1.64% a Tyrrhenian provenance, 0.16% a Gallic provenance, and 0.03% a North African provenance. The most commonly attested Eastern amphora was the Camulodunum 184 from the Aegean, which made up 5.29% of the entire assemblage (see Figure 6.42).²⁷ The rest of the Eastern vessels, with the exception of Eastern Dressel 2-4s, were each found in quantities of <1%. Given the variety of vessels attested and their low quantities, it is difficult to tell whether these forms were transported in bulk, selectively imported to meet specific demands, or represent the movement of people. The contents of the Eastern amphorae within the region seems to have been almost uniformly wine. Iberian imports were predominantly Dressel 7-11 fish sauce amphorae, which formed 2.81% of the total assemblage and were found at most sites (see Figure 6.43).²⁸ Other fish product carrying vessels, such as Dressel 12, and Dressel 14, Beltrán 2A, were also widely distributed across the study area, although to a far lesser extent (see Figures 6.44, 6.45, and 6.46).²⁹ The other major Iberian vessel imported at this time was the Dressel 20 oil amphora, which saw some circulation, particularly in the far west and south-west of the study area (see Figure 6.47).³⁰ Tyrrhenian imports consisted almost solely of Dressel 2-4 wine amphorae, with the other vessel of note being a small number of Richborough 527 alum amphorae from Lipari (see Figure 6.48).³¹ Both Gallic and North African imports appeared in very small quantities, with all vessel types forming < 1% of the total assemblage. The most common Gallic imports were the flat-bottomed Gauloise 2 and Gauloise 4 wine amphorae, while North African imports were almost entirely composed of oil-carrying Africana 1 amphorae (see Figures 6.49,

early first-mid second century AD, some variants seem to last into the late second–early third century AD.

²⁶ For information on the Dressel 2-4, see: https://archaeologydataservice.ac.uk/archives/view/amphora_ahrb_2005/details.cfm?id=102 (Accessed 16/12/2021).

²⁷ For details of the Camulodunum 184, see: https://archaeologydataservice.ac.uk/archives/view/amphora_ahrb_2005/details.cfm?id=74 (Accessed 16/12/2021).

²⁸ For details of the Dressel 7-11, see: https://archaeologydataservice.ac.uk/archives/view/amphora_ahrb_2005/details.cfm?id=115 (Accessed 16/12/2021).

²⁹ For details of the Dressel 12, see: https://archaeologydataservice.ac.uk/archives/view/amphora_ahrb_2005/details.cfm?id=67 (Accessed 16/12/2021). For details of the Dressel 14, see: https://archaeologydataservice.ac.uk/archives/view/amphora_ahrb_2005/details.cfm?id=68 (Accessed 16/12/2021). For details of the Beltrán 2A, see: https://archaeologydataservice.ac.uk/archives/view/amphora_ahrb_2005/details.cfm?id=43 (Accessed 16/12/2021).

³⁰ For details of the Dressel 20, see: https://archaeologydataservice.ac.uk/archives/view/amphora_ahrb_2005/details.cfm?id=83 (Accessed 16/12/2021).

³¹ For details of the Richborough 527, see: https://archaeologydataservice.ac.uk/archives/view/amphora_ahrb_2005/details.cfm?id=286 (Accessed 16/12/2021).

6.50, and 6.51).³²

There was more diversity amongst the types of cargoes carried by amphorae during the first-second centuries AD. Wine carrying vessels continued to be the most common, forming approximately 55% of the first-second centuries AD assemblage and most prominent cargo across the sites (see Figure 6.52). In this period, oil seems to have been more widely transported by amphorae, making up 39% of the recovered vessels. While imports of fish product amphorae did increase, they formed a relatively minor number of total imports, making up only 6% of transport vessels.³³ Commodities other than wine, oil, and fish products, were recovered in exceptionally small quantities, with containers carrying alum, *defrutum*, fruit, and olives each making up < 1% of the total assemblage. Measuring the quantity of each vessel contents by volume did little to change the overall picture (see Figure 6.53). Wine still dominated, with oil coming second, fish products a distant third, and other commodities appearing in minimal quantities. Hierarchical clustering failed to identify any patterns in the distribution of these commodities across Northern Italy. The percentage composition of each assemblage's contents was analysed using both vessel count and volume, with neither returning any visible geographic patterns.

The majority of wine (61%) in the first-second centuries AD came from the Adriatic, transported in Dressel 6A and Flat-Bottomed Italic amphorae (see Appendix C). This was followed by Eastern wine imports, which made up 25% of wine carrying vessels. Gallic, Iberian, and Tyrrhenian vessels made up <0.5% of wine imports. A similar picture emerges for imports of oil, with the Adriatic supplying 91% of oil-bearing vessels recovered in the region. Dressel 6Bs formed the principal oil-carrying amphora; with the Anfora con Collo ad Imbuto form also contributing. Both Iberian and North African vessels formed <1% of oil imports. Fish products seem to have been predominantly imported from the Iberian Peninsula (69%) in Dressel 7-11s, closely followed by the Adriatic (27%), which was transported in Grado 1 and Anforette Adriatiche da Pesce amphorae.³⁴ This pattern should be viewed with caution, especially considering the known reuse of

³² For details of the Gauloise 2, see: https://archaeologydataservice.ac.uk/archives/view/amp_hora_ahrb_2005/details.cfm?id=134 (Accessed 16/12/2021). For details of the Gauloise 4, see: https://archaeologydataservice.ac.uk/archives/view/amphora_ahrb_2005/details.cfm?id=136 (Accessed 16/12/2021). For details of the Africana 1, see: https://archaeologydataservice.ac.uk/archives/view/amphora_ahrb_2005/details.cfm?id=1 (Accessed 16/12/2021).

³³ This number seems unusually small. De Sena's ((2005), 2) calculations from the DAI-AAR excavations at Ostia suggest a greater quantity of fish product were imported than oil products (22 million vs. 20 million litres). Given evidence for the re-use of oil and wine amphorae for fish products in the region (see below), the percentage of amphora-borne fish products in the first-second centuries AD is probably higher than the amount indicated here.

³⁴ For information on the Grado 1 and Anforette Adriatiche da Pesce, see: Carre et al. (2009); Mongardi (2014), 353-56.

Dressel 6A wine amphorae and Africana 1 oil amphorae in carrying fish sauce and preserved fish originating from the Adriatic coast.³⁵ Adriatic fish products may well have formed a higher percentage of consumption than is currently visible, although without widespread residue analysis this remains hypothetical. The rest of the commodities, alum, *defrutum*, fruit, and olives, had varied provenances, perhaps reflecting the more specialised or specific nature of the product.

When sites in the first-second centuries AD dataset were hierarchically clustered using the UPGMA algorithm based on the provenance of their assemblages, three geographic clusters were identified (see Figure 6.54 and 6.55). The first cluster comprised nine sites dominated by Adriatic amphorae, which ranged from 76.6% of the assemblage at Calvatone to 100% of the assemblages at Bologna and Reggio Emilia. Adriatic vessels were complemented by very low numbers of other imports, principally of an Eastern provenance. These range from 2% of the assemblage at Este to 12.8% of the assemblage at Forlì. Some Iberian and North African vessels were attested, but Gallic and Tyrrhenian vessels were present in minimal quantities. All sites within this cluster were located on the coastal plain and the eastern and central Po-valley, specifically on the valley floor. The first cluster contained three sub-groups, two of which grouped geographically. The first group comprised Este, Forlì, Padua, and Vicenza, sites where Adriatic vessels formed over 85% of the assemblages and those closest to the coast. The second group comprised Calvatone, Cremona, and Brescia sites where Adriatic vessels formed over 67% of the assemblages and those located further inland within the eastern and central Po valley. The third group comprised the sites of Bologna and Reggio Emilia, the assemblages of which were entirely made up of Adriatic material.

The second cluster comprised ten sites, located further inland within the north-west and centre of the Po plain, alongside the Alpine foothills and valleys. Oderzo formed an outlier, located on the coastal plain. Adriatic vessels still formed the majority of each assemblage in this cluster, ranging from 54.5% at Milan to 76.8% at Oderzo. However, these sites contained a far greater percentage of amphorae from other provenances. Eastern amphorae accounted for the second largest group, ranging from 10% of the assemblage at Vercelli to 35.6% in Milan. Iberian vessels made up the next most common provenance, ranging from 1.3% at Oderzo to 20.5% at Vercelli. Tyrrhenian and North African imports remained low, generally under 2%. The exception to this was Verona, where North African vessels made up 7.5% of the assemblage. The second cluster contained three sub-groups but these did not group geographically.

³⁵ Auriemma (2000), 42-45; Mazzocchin and Wilkins (2013).

The third and final cluster contained sites located in the west and south-west of the Po valley, the areas closest to the Ligurian Apennines and the Western Alps, and furthest away from the Adriatic coast. Adriatic vessels still formed the main component of each assemblage, ranging between 44.1% and 48.5% of each site assemblage. These were complemented by much greater diversity in the provenance of the remaining vessels present at each site, including significant quantities of Western Mediterranean amphorae. No single provenance formed the second largest across the cluster, with quantities differing across the sites. Eastern vessels accounted for between 2.8% of the assemblage at Libarna and 32.1% of the assemblage at Ivrea; Iberian vessels ranged from 17.4% at Alba to 38.5% at Libarna; Gallic vessels ranged between 7.1% at Libarna and 11.2% at Augusta Bagiennorum; and Tyrrhenian imports between 1.6% at Libarna and 9.8% at Augusta Bagiennorum. These were the highest concentrations of these provenances for any area of the region. North African imports, however, remained in quantities below 2% of each assemblage. There were no sub-groups within the cluster.

The addition of assemblages from the Adriatic and Ligurian ports to the hierarchical analysis did not significantly change the distribution of inland sites within the clusters. With the exception of Ariminum, the Adriatic ports clustered with sites in the north-western Po valley and the Alpine foothills, rather than those in their immediate vicinity (see Figure 6.56). This was due to the higher level of Eastern vessels in their assemblages when compared to nearby sites such as Forlì and Padua, the assemblages of which consisted almost solely of Adriatic vessels. In contrast, the Ligurian ports showed minimal similarity to any site in the makeup of their assemblage, with Luna and Porto Maurizio forming a separate cluster (see Figure 6.57). Sites in the south-west of the Po valley, despite having the quantities of Western Mediterranean amphorae in their assemblages, continued to share more in common with other sites contained within Northern Italy than those on the Ligurian seaboard.

The higher level of diversity in the provenance of inland assemblages was also reflected in the vessel forms recovered from each site during the first-second centuries AD. When measured with Simpson's Index, all but one site scored above 0.5, suggesting a greater level of diversity than uniformity amongst the vessels comprising each assemblage (see Figure 6.58). Furthermore, Simpson's Index indicated an overall higher level of diversity in the makeup of the assemblages compared to the preceding period, with most sites returning a score of 0.75 or above. Port sites exhibited some of the highest diversity scores, generally scoring above 0.9. In contrast, sites in proximity to ports on the Adriatic coastal plain and eastern Po valley, such as Este, Modena, Padua, and Vicenza, returned some

of the lowest scores. Sites in the upper valley and Alpine foothills had some of the highest diversity scores for inland sites, all scoring above 0.79 thanks to their ability to draw from both eastern and western goods. The highest, 0.88, belonged to Acqui Terme in the south-west of the Po valley. Industria formed an outlier, returning the second lowest diversity score from first-second centuries AD assemblages despite being located in the upper valley.³⁶

Results were less clear when the assemblages were analysed using the Morisita-Horn Overlap Coefficient, although the overall pattern of lower diversity and greater uniformity in the central valley and coastal plain, matched by higher diversity and lower similarity amongst assemblages in the north-west and south-west of the Po valley held. The majority of sites in the coastal hinterland and eastern valley formed a single cluster, while several sites in the west and south-western valley formed a second (see Figure 6.59). Novara and Vercelli joined the first cluster despite being located in the western valley, while Brescia and Altinum joined the second cluster despite being located on the coast. Sites in the first cluster covering the central and eastern valley had very high levels of similarity, most assemblages scoring below 0.13. The level of overlap was lower (although still high) for sites in the second cluster, with most of its sites scoring below 0.25. Beyond these two main clusters, a small cluster of two sites, Augusta Bagiennorum and Industria also formed. The sites of Civitate Camuno, Ivrea, Libarna, and Trento did not join clusters but placed independently, suggesting a low level of similarity to other assemblages. These unclustered sites were all located in either the south-west of the region or in the Alpine valleys. All the Adriatic ports bar Altinum formed a cluster (alongside Forlì), as did the two Ligurian ports. Both port clusters had low levels of overlap with the assemblages of inland sites.

The similarity of first-second centuries AD amphora stamps between sites within the CEIPAC database was compared using the Morisita-Horn Overlap Coefficient. The majority of vessels from Northern Italy within the CEIPAC amphora had an Adriatic provenance, with the Dressel 6B the most prominent vessel type (see Figure 6.60). When the results were displayed in a dendrogram, few geographic patterns could be observed in the data (see Figure 6.61). Several clusters formed, although only one of four sites (Castelfranco Emilia, Piacenza, Parma, and Reggio Emilia, along the line of the via Aemilia) grouped geographically.³⁷ Many of the stamp assemblages had no overlap with any other site, while

³⁶ Zanda (2011), 30-32. This can be explained by the low number and lack of variety of vessels within the assemblage due to its partial publication.

³⁷ A geographic sub-group of sites in one of the clusters, consisting of Oderzo, Padua, and Vicenza, had some of the highest levels of overlap in their stamp assemblages, but other sites within the cluster were located across Northern Italy.

the overall level of similarity between the remaining sites in the dataset remained low.

In summary, amphora-borne trade in Northern Italy during the first-second centuries AD continued to be dominated by goods produced along the Adriatic littoral, principally oil and wine from Istria and Italy's western coast. However, during this period, a greater variety of other goods from further afield began to circulate within the region. While they formed less than 40% of the total amphorae transported, these vessels were not evenly distributed across Northern Italy. Although sites in the coastal hinterland continued to be dominated by Adriatic imports, sites further inland saw more variety, with Eastern imports in particular taking up a wider share of each assemblage. Assemblages for sites in the west and south-west of the Po valley, those at the greatest distance from the Adriatic ports, exhibited very different provenances for their amphorae. Vessels from the Adriatic and Eastern Mediterranean appeared in lower quantities at these sites, with imports from the Western Mediterranean accounting for a large percentage of their assemblages. These inland sites generally exhibited higher levels of diversity and lower overlap in the composition of their assemblages compared to those closest to the Adriatic coast.

6.3.3 The Third-Fifth Centuries AD

A total of seven sites within the amphora dataset returned more than thirty sherds from the third-fifth centuries AD, and the small sample size means that results should be treated with a degree of caution.³⁸ The amphora data from the third-fifth centuries AD was vastly different from the preceding two periods, with Adriatic and Gallic vessels disappearing. During this period, amphorae originated from four different zones of production: the Eastern Mediterranean, the Iberian Peninsula, North Africa, and the Tyrrhenian coast (see Figures 6.62, and 6.63). Eastern vessels were the most numerous, making up 52.4% of the third-fifth centuries AD assemblage, followed by North African which made up 40.5% of total imports. Amphorae of an Iberian and Tyrrhenian provenance accounted for 4% and 2.9% of the third-fifth centuries AD assemblage respectively.

Sixty vessel forms were attested in Northern Italy during the third-fifth centuries AD, although no form dominated in the same way as the Lamboglia 2 and the Dressel 6A/6B had done during the Late Republic and first-second centuries AD (see Figures 6.64 to 6.68).³⁹ The most prominent vessels amongst the Eastern imports included the Almagro 54 wine amphora from Palestine, which made up

³⁸ The CEIPAC amphora database also contained no stamped vessels dated to this period.

³⁹ Thirty-nine of the sixty vessel forms from this period comprised <1% of the total assemblage.

20.83% of the assemblage, followed by the LRA 3 form from Western Asia Minor, which accounted for 10.77% (see Figures 6.69 and 6.70).⁴⁰ From North Africa, the Spatheion 1 amphora composed 11.4% of the total third-fifth centuries AD assemblage, followed by the Africana 3, which accounted for 7.54% (see Figures 6.71 and 6.72).⁴¹ The various subclasses of the Africana 2 form were also prominent, together comprising 9.3% of the total assemblage (see Figure 6.73).⁴² The most common Iberian imports were the Almagro 51A-B and Almagro 51C fish sauce amphorae, each accounting for 1.15% of the total assemblage (see Figures 6.74 and 6.75).⁴³ Finally, Tyrrhenian vessels made up the final 2.9% of vessels, which were almost entirely composed of Keay 52 amphorae from Southern Calabria (see Figure 6.76).⁴⁴

When assessing contents via the number of vessels, wine seems to have been the most prominent amphora-borne product during the third-fifth centuries AD, occupying 66% of containers (see Figure 6.77). Oil once again came second with 18%, and fish products third with 16%. There was no evidence within the dataset of other amphora-borne products circulating within the region during the third-fifth centuries AD. When the quantity of each commodity was measured by volume instead of vessel count, this picture changed drastically (see Figure 6.78). Oil became the most prominent import, now making up 41% of the total volume. Wine was the second most common, making up 38% of the volume, with fish sauce accounting for the final 21%. The shift from oil to wine as the main import during this period may reflect a change in containerisation rather than a change in demand. Oil predominantly travelled long distances in amphorae, however, during this period wine was increasingly transported via barrel (see Section 6.6). As barrels are not preserved in the archaeological record to the same extent as amphorae, the quantity of wine imported during this period is probably under-represented. North Africa seems to have been the main supplier

⁴⁰ For information on the Almagro 54, see: https://archaeologydataservice.ac.uk/archives/view/amphora_ahrb_2005/details.cfm?id=16 (Accessed 16/12/2021). For information on the LRA 3, see: https://archaeologydataservice.ac.uk/archives/view/amphora_ahrb_2005/details.cfm?id=240 (Accessed 16/12/2021).

⁴¹ For information on the Spatheion 1, see: https://archaeologydataservice.ac.uk/archives/view/amphora_ahrb_2005/details.cfm?id=289 (Accessed 16/12/2021). For information on the Africana 3, see: https://archaeologydataservice.ac.uk/archives/view/amphora_ahrb_2005/details.cfm?id=208 (Accessed 16/12/2021).

⁴² For information on the Africana 2, see: https://archaeologydataservice.ac.uk/archives/view/amphora_ahrb_2005/details.cfm?id=3 (Accessed 16/12/2021).

⁴³ For information on the Almagro 51A-B, see: https://archaeologydataservice.ac.uk/archives/view/amphora_ahrb_2005/details.cfm?id=13 (Accessed 16/12/2021). For information on the Almagro 51C, see https://archaeologydataservice.ac.uk/archives/view/amphora_ahrb_2005/details.cfm?id=15 (Accessed 16/12/2021).

⁴⁴ For information on the Keay 52, see: https://archaeologydataservice.ac.uk/archives/view/amphora_ahrb_2005/details.cfm?id=161 (Accessed 16/12/2021).

of amphora-borne oil and fish products to the region, while wine was predominantly carried by Eastern vessels. Iberian imports almost solely consisted of fish products, with some sporadic instances of wine and oil. There was no obvious pattern in the distribution of these imports across Northern Italy and hierarchical clustering failed to identify any underlying patterns to the data.

When sites in the third-fifth centuries AD dataset were hierarchically clustered using the UPGMA algorithm based on the provenance of their assemblages, two clusters formed (see Figures 6.79 and 6.80). The first cluster was comprised of two sites, Brescia and Verona. The assemblages of Brescia and Verona were composed of roughly equal parts Eastern and North African amphorae (49.7/45.5% Eastern and 41.3/45.5% North African respectively). The second cluster was composed of Milan and Trento, with the assemblages of both sites dominated by Eastern amphorae (81.4% and 98.8% respectively). Ivrea placed independently of either cluster due to the high percentage of Iberian vessels (37%) within its assemblage. While the low number of sites makes interpretation difficult, the first cluster broadly represents sites in the centre and eastern Po valley, while the second cluster includes a site in the north-west and the Alpine valleys. Ivrea, by itself, represents the western Po valley. This is not dissimilar to the distribution of clusters seen during the preceding period. The addition of the Adriatic ports to the analysis did not change this pattern, with Altinum and Aquileia forming a third cluster of two sites (see Figure 6.81).⁴⁵

When measured with Simpson's Index, all but one site in the third-fifth centuries AD dataset scored above 0.6, suggesting a greater level of diversity than uniformity amongst the vessels comprising each assemblage (see Figure 6.82).⁴⁶ Port sites returned the highest scores for diversity, with Aquileia and Altinum scoring 0.94 and 0.87 respectively. This was followed Brescia and Verona, which also scored 0.87, while Milan and Trento scored lowest. This marked a reversal from the previous period, with sites in the central and eastern Po valley showing greater diversity than those further inland. When analysed using the Morisita-Horn Overlap Coefficient, four of the six sites formed a cluster with Aquileia and Trento placing independently (see Figure 6.83). Most sites scored below 0.35 for the distance between their assemblages. Although this continued to suggest a high level of overlap in the vessels present at each site, this had decreased from the first-second centuries AD. No obvious geographic pattern could be drawn from the data.

⁴⁵ No Ligurian port returned an assemblage from the third-fifth centuries AD.

⁴⁶ Ivrea was excluded from the diversity analysis due to only the provenance of its assemblage being identified, rather than the forms within it.

6.4 Discussion: The Late Republic

The distribution of amphorae in Northern Italy during the Late Republic demonstrates that the mechanisms needed to transport large quantities of goods inland were already in place during this earlier period. The Adriatic coast formed the main entry point for goods entering the region, with the Po forming the main axis of trade from east to west. Amphora imports, overwhelmingly the Lamboglia 2 form, were found in large numbers at sites across the study area. While the Po-Veneto plain formed a principal market for the Lamboglia 2, its wider distribution was not limited to the Po valley, and the form is found extensively not just in the Adriatic, but also along the western coast of Italy, in Southern Gaul, and Western Iberia (see Figure 6.84).⁴⁷ Tyrrhenian imports, uniformly Dressel 1 wine amphorae, formed the next most common provenance, although, for the most part, constituted a minor percentage of each assemblage. Imports from other provenances appeared in negligible quantities. The Late Republican assemblages show uniformity across the region, exhibiting low diversity and a high level of overlap in the vessel forms they contained. The low diversity, both in provenance and assemblage contents, reflects the lack of choice available to consumers during this period, with zones of production in Gaul and Iberia yet to be fully established and Eastern amphorae only just beginning to penetrate into the Adriatic.⁴⁸

Despite the dominance of the Lamboglia 2 and other Adriatic imports, there is evidence for some divide between assemblages in the east and the west of the valley. Several sites in the west and south-west of the Po valley exhibited a higher level of vessel diversity than those in the east. These western assemblages also demonstrated a higher percentage of Tyrrhenian vessels, reaching a maximum of 29.9% Ivrea. While minor numbers of Iberian and North African vessels at sites in the central and eastern valley during this period probably reflect one-off purchases as opposed to sustained imports, the higher number of Tyrrhenian vessels seen at Ivrea may represent a deliberate move to tap into markets on the western coast of Italy. Sites in the west of the valley were the only ones in Northern Italy located to take advantage of Tyrrhenian imports in a significant way. The low number of Tyrrhenian vessels recovered from the east of the valley suggests that Dressel 1 amphorae were entering the region over the Apennines, with the *via Postumia*, constructed in 148 BC, being the obvious route. The costs and logistics of transporting these vessels across the mountains would have made it prohibitive to transport them further east than areas in the immediate

⁴⁷ Lindhagen (2009), 95-97; Righini (2004), 240-44.

⁴⁸ Auriemma and Quiri (2004); Auriemma et al. (2015).

vicinity of the Apennines.

The Late Republican assemblages demonstrate that amphora-borne goods in Northern Italy were almost exclusively supplied by areas in the region's immediate vicinity during this period. Northern Italy was strongly integrated into the Adriatic economy and its predominant imports travelled a very short distance to reach their destination. There were fewer connections to Western Italy, but significant quantities of Tyrrhenian amphorae were able to supply the western Po valley. The penetration of significant quantities of Adriatic amphorae into the far west of the Po valley suggests that the region's networks of transport and redistribution were already relatively sophisticated during this period, especially considering most infrastructure investment would take place in the following century (see Section 3.1.5). Connections to wider extra-provincial economies located in the Western and Eastern Mediterranean were overall limited during this period, but the networks that future imports would travel along were already in place by the Late Republic.

6.5 Discussion: The First-Second Centuries AD

The first-second centuries AD saw an increase in the number of provenances and vessel types available in Northern Italy. As new zones of production were established and inter-provincial trade increased, communities were presented with a greater choice in the goods they consumed. Amongst the continuity of earlier trade networks, amphora-borne produce from new sources began to appear within the region.

6.5.1 Adriatic Production and Regional Markets

Imports of amphorae in the first-second centuries AD built upon the trading patterns of the Late Republic, with a continued focus on local and regional zones of production. The Lamboglia 2 was replaced by the Dressel 6A as the dominant wine-carrying vessel, with production sites expanding further inland as far as Parma during the late first century BC–early first century AD.⁴⁹ The majority of Dressel 6As seems to have originated from the area around Picenum in the Middle Adriatic by the early first century AD.⁵⁰ From the late first–early second century AD Flat-Bottomed Italic forms would start being produced in the area south of Ravenna to carry locally made wine, replacing the Dressel 6A. Fabric analysis suggests there was some Dressel 6B production in the area around the

⁴⁹ Marini Calvani (1981), 127-29.

⁵⁰ Cipriano and Mazzocchin (2018), 261-62; (2019), 242-43.

Euganean and Berici hills, alongside the area around Verona, although kiln sites have yet to be found.⁵¹ The production of Dressel 6Bs in this area seems to have tailed off by the mid-first century AD, with most examples originating from Istria beyond this point.⁵² The Anfora con Collo ad Imbuto, the morphological successor to the Dressel 6B, was also produced in Emilia-Romagna, Istria, and the Middle Adriatic.⁵³

In comparison to the Lamboglia 2, which saw widespread dispersion beyond its area of production, the Dressel 6A and Dressel 6B saw very limited distribution. This was divided between the Northern Italy, the Central and Southern Adriatic, and the Danubian *Limes* (see Figures 6.85 and 6.86). Of these, Northern Italy has the greatest concentration of findspots for these amphora forms. This reflects expanding wine production in new areas such as Southern Gaul and the Iberian Peninsula during the Early Empire, and the rising connectivity that allowed the mass transport of this wine to new markets. The comparative advantage that these new producers enjoyed made the Dressel 6A uncompetitive over the long distances the Lamboglia 2 had previously travelled. Instead, Adriatic wine production seems to have responded to these market changes and refocused on supplying Northern Italy, with the period also seeing a massive expansion in Adriatic oil production to meet similar demand both within Northern Italy and on the Danubian *Limes*.⁵⁴ The stamp data points to the breadth and variety of Adriatic producers and traders involved in this exchange, with assemblages across the Late Republic and first-second centuries AD, exhibiting low levels of similarity in the amphora stamps they contained. There was little overlap in the stamps attested at each site, suggesting that no specific area of Adriatic production dominated inland trade.⁵⁵ The geographic cluster of stamp assemblages on the via Aemilia presents the possibility that some Adriatic producers had their amphorae traded along specific routes, but the low quantity of data at many sites makes it difficult to ascertain if this is a genuine pattern.⁵⁶

Amongst the Adriatic vessels from the first-second centuries AD, the most unexpected distribution pattern was that of the Flat-Bottomed Italic amphora.

⁵¹ Cipriano and Mazzocchin (2004), 108-10; Maritan et al. (2019). Oil production in general is poorly attested in this part of Northern Italy. See Busana et al. (2009), 35-41, for a synthesis of the available archaeological evidence from the region.

⁵² Cipriano (2009), 183.

⁵³ Maritan et al. (2019); Mazzocchin (2009), 198-200. This is on the basis of archaeometric and stamp data.

⁵⁴ Van Limbergen (2018) provides a good analysis of the evolution of Central Adriatic wine production during the Late Republic and Early Empire. See Egri (2007) on the consumption of Adriatic oil on the Danubian *Limes*.

⁵⁵ Cipriano (2016), 146-54; Cipriano and Mazzocchin (2012), 241-50; (2019), 239-42.

⁵⁶ The low number of stamps at some sites may mean the level of overlap is much higher than the results suggest.

With its flat base, the amphora's shape would have been ideally suited for river transport on flat-bottomed, shallow draught barges on the water network of the Po-Veneto plain. In this respect, it would have joined other flat-bottomed vessels, such as the Dressel 28, Gauloise 4, Spello forms that were traded along the rivers of Baetica, Gaul, and Italy respectively.⁵⁷ Yet, as mentioned above, there is minimal distribution of Flat-Bottomed Italic amphorae inland and they are barely attested at sites in their immediate vicinity such as Forlì.⁵⁸ They instead seem to travel primarily along the coast and the para-littoral canal system, transporting the form to Ravenna, Altinum, and Aquileia where it was subsequently exported overseas.⁵⁹

6.5.2 Changing Zones of Consumption

Within the first-second centuries AD dataset, hierarchical clustering revealed three distinct geographic clusters of sites based on the provenance of their assemblages. The first of these was located in the coastal plain and central valley, and was mainly dominated by amphorae of an Adriatic provenance. Assemblages within this cluster returned low scores for their diversity and had high levels of overlap in their components. Given the proximity of sites within this cluster to the coast and Adriatic ports, the low quantities of other imports present was surprising. Furthermore, the Adriatic ports themselves did not place within this cluster. The assemblages of port sites had a more varied provenance and greater diversity of material, instead grouping with sites in the north-west of the Po valley.⁶⁰ Coastal hinterlands have been promoted as some of the best-connected areas in the Roman world due to their proximity to maritime trade routes.⁶¹ While this is reflected in the network model analysed in Chapter 4, greater connectivity does not seem to have translated into a greater variety of imports for sites in the immediate vicinity of the coast.

The dominance of Adriatic amphorae and low variety of vessel forms in the central and eastern Po valley and the coastal plain may be due to a number

⁵⁷ Spello amphorae were primarily produced in the Tiber valley and were transported down river to Rome (Patterson and Lapadula (1997), 128). The main axis of trade for the Gauloise 4 was inland up the Rhône towards the frontier provinces (Remesal Rodríguez and Revilla Calvo (1991)). The Dressel 28 was ideally suited to be transported down the Guadalquivir valley to sites on the coast and beyond (García Vargas et al. (2011)).

⁵⁸ This is perhaps unsurprising, as amphorae were primarily designed for long-distance transport. Wine travelling over shorter distances may have been stored in other containers, such as skins (Tchernia (1986), 285-92).

⁵⁹ Aldini (1999); (2000). This was mainly concentrated in the Eastern Mediterranean (Panella (2002), 195-96).

⁶⁰ The more varied provenance of their assemblages probably reflects their role as *entrepôts* through which most imported goods travelled.

⁶¹ Horden and Purcell (2000), 115-22; Scheidel (2014), 14; Wilson et al. (2012), 384.

of reasons. Low transport costs afforded by the density of the river and road networks in this part of the region allowed large quantities of Adriatic goods to penetrate significant distances inland, explaining why sites in the centre of the Po valley, such as Cremona, had similar assemblage compositions to those on the coastal plain. In addition, sites in the central and eastern Po valley and the coastal plain had initial access to Adriatic imports, which had travelled the least distance at that point in time.⁶² The available quantity and presumably lower prices of Adriatic imports may have been favoured over more exotic or unusual goods on the market, with specific product choice less of a concern.

The second geographic cluster was formed of sites mainly located in the Alpine foothills and north-west of the Po valley. Its sites were at a greater distance inland than those on the coastal plain and central valley or were placed in peripheral locations in the foothills off the valley floor. Although Adriatic amphorae were still present in the greatest quantities, other goods arriving from the Adriatic coast seem to have become more competitive. The Po valley's geography naturally facilitated access to markets in both the Adriatic and Eastern Mediterranean, and Eastern wine amphorae appear in increasing quantities within this cluster.⁶³ Due to the presence of both Adriatic and Eastern amphorae, sites in this cluster also exhibited greater diversity in the vessel forms within their assemblages.

The reduction in the quantities of Adriatic vessels at sites in the Alpine foothills and north-west of the Po valley could be a result of several factors. The first of these is price. Sites in this cluster, at a greater distance from the coast or located at the end of navigable rivers, incurred a greater transport cost to reach than those in the central valley and coastal plain. Rising transport costs may have served to remove the comparative advantage Adriatic amphorae held due to the proximity of their production to Northern Italy, making Eastern amphorae more competitive in price as distance from the coast increased. Consumers may have made the deliberate choice to purchase Eastern wine over Adriatic wine in this case. As a high-quality, 'exotic' import, amphora-borne Eastern wine was probably better able to absorb the transport costs incurred to reach these parts of Northern Italy. The greater quantity of Eastern amphorae in this part of the region may also reflect Adriatic producers struggling to satisfy demand in areas

⁶² Dressel 6A and 6B amphorae produced in eastern Emilia-Romagna and the Veneto plain would have travelled the least distance of all, making them the most competitive (Carre et al. (2014); Cipriano and Mazzocchin (2019); Maritan et al. (2019)). For the reasons outlined in Chapter 5, it is currently impossible to quantify more specific zones of production for the Adriatic vessels in each site report.

⁶³ The Eastern Mediterranean formed the second-largest provenance for imported amphorae across Northern Italy. Eastern amphorae were imported in significant quantities across the wider Adriatic area during the first-second centuries AD. Some sites on the coast of the Southern Adriatic see Eastern imports exceed 60% of assemblages (Auriemma and Quiri (2004), 43-44).

further inland, forcing consumers to turn to other zones of production to make up the shortfall. Regardless of the reason, it is evident that Adriatic vessels no longer enjoyed a monopoly on amphora-borne trade beyond the central valley, a trend that continued into the south-west of the Po valley.

The final cluster was comprised of sites in the west and south-west of the Po valley, and the provenance of amphorae within these assemblages diverged significantly from those in the previous two clusters. Sites in the west and south-west of the Po valley contained high quantities of Western Mediterranean amphorae, originating from Gaul, the Iberian Peninsula, North Africa, and the Tyrrhenian Coast. Sites in the cluster, despite being located at the greatest distance from the Adriatic coast, also returned the highest scores for diversity aside from port sites within the region.

While the geography of Northern Italy naturally orientates its connections east, the south-west of the valley is located a short distance from the Ligurian Sea. Separated by the Apennine mountains, Ligurian ports such as Genoa offered an alternative entry point for goods to enter the region. By the time Adriatic and Eastern amphorae had travelled into the west and the south-west of the Po valley, prices may have risen to such an extent that Western Mediterranean goods crossing the Apennines became competitive.⁶⁴ Alternatively, as with the north-west of the valley, a combination of Adriatic and Eastern goods may not have been enough to fulfil demand in this part of the region, forcing it to turn to other markets. The existence of trans-Apennine trade and the presence of Western Mediterranean goods in the south-western Po valley has been commented on before, but the intensity of this traffic has never been quantified.⁶⁵ As the above analysis shows, Western Mediterranean imports comprised between 23.1% and 48.5% of assemblages within this cluster, suggesting significant trans-Apennine trade despite the obstacle posed by the mountains.

Although it is clear that Western Mediterranean amphorae played an important part in supplying the south-western Po valley, these goods were only competitive in a small area of Northern Italy. The transport costs incurred during their overland journey from the Ligurian coast put them at an increasing disadvantage the further inland they progressed, especially in areas connected to the water network. As highlighted above, they achieved little to no penetration at sites further to the north and east of this part of the region. Even in the south-west, it is important to highlight that the majority of each assemblage was still

⁶⁴ Imports of Gallic amphorae were probably traded along the coast and over the Apennines, rather than across the Alps. Although some goods did cross the Alps in significant quantities (see Gabucci (2017) and Chapter 7 of this thesis), these were mostly smaller than amphorae and were traded for their items themselves, not their contents.

⁶⁵ Bruno (1998); Filippi (1995); Melli (2004).

composed of Adriatic and Eastern amphorae, the Po valley and Adriatic remaining the main axis of trade.⁶⁶ The low level of similarity between the assemblages in the west and south-west of the Po valley and ports on the Ligurian seaboard further reinforces this view, with neither Ligurian port joining this cluster.

6.5.3 The Question of Choice

Although cost and supply played a significant role in the distribution of amphorae, consumer choice could also have been a factor in the provenance of each assemblage. Across the sites of Northern Italy, the division of amphora contents within each assemblage remained consistent, suggesting the provenance of the vessels played a greater part in the consumer's choice rather than their contents. Although demand for goods was fairly uniform across the region, different solutions were used to meet it.

If prices for Adriatic goods travelling up the Po valley began to match those for goods coming from the Eastern Mediterranean or over the Apennines, then buyers might choose to make purchases based on the quality of a product, rather than simply choosing the provenance with the lowest cost.⁶⁷ For example, although Southern Gaul and the Tyrrhenian coast were the next closest production areas geographically to the west of the Northern Italy, the Iberian Peninsula formed the most prominent origin of western imports. It is striking that the majority of Iberian imports are fish sauce, as opposed to the wine principally carried by Gallic and Tyrrhenian vessels. The higher presence of Iberian imports in the west of Northern Italy may consequently be a result of fish sauce producers on the Adriatic coast being unable to compete with Spanish products on either quality or cost of product.⁶⁸ In a similar vein, the continued presence of Adriatic wine in the west of the study area may be due to it being deliberately favoured

⁶⁶ Northern Italy did not form a principal market for western amphorae, with their production largely directed towards other areas of consumption. For Gallic amphorae, the Rhône valley and the German *Limes* probably formed the predominant axis of trade, with some distribution across the Western Mediterranean (Remesal Rodríguez and Revilla Calvo (1991); Rice (2012), 251-57). In a similar vein, Tyrrhenian wine production sees distribution into Southern Gaul and the northern frontier, while Rome also formed a major market for both Gallic and Tyrrhenian production (De Sena (2005), 8-9). For Iberian imports, Rome and the *Limes* also formed the main market for Spanish oil, though wrecks such as the *Culip IV* point to a trading triangle that included the Eastern Iberian Peninsula, Southern France, and Western Italy (Nieto et al. (1989), 239-44). While Iberian, Gallic, and Tyrrhenian vessels may have made their way along the Ligurian coast, appearing at Porto Maurizio and Luna in significant quantities, the direction of trade seems to have para-littoral, rather than inland.

⁶⁷ For discussions on consumer choice in the Roman period through the application of material studies, see Allison (2004); Greene (2008); Laurence and Trifilò (2015); Pitts (2013); (2015).

⁶⁸ Pliny, *Natural Histories*, 31.43, suggests that some specific producer's fish sauces were esteemed for their high quality, and mentions some areas of the Iberian Peninsula as a producer of some of the best.

over Gallic and Tyrrhenian wine.⁶⁹ It is also possible these patterns instead represent opportunistic buying in response to fluctuations in production or price in the Adriatic. While the location of sites in the west and south-west of the Po valley, at the end of the Po transport corridor, left them especially vulnerable to such changes, their proximity to ports on the Ligurian coast meant they were better placed to take advantage of alternative extra-provincial markets in the event of such a scenario. Such a scenario would be reliant on free-market forces, with buyers and sellers having the requisite knowledge to capitalise on changes in price.⁷⁰

The amphora data from the first-second centuries AD demonstrate the various levels of economic activity and networks of exchange present across Northern Italy. The region's strongest ties were with areas in its immediate vicinity and its predominant imports travelled a very short distance, with production areas in the Adriatic almost exclusively supplying the Northern Italian market with oil and wine. This was especially true for the east of the valley, where sites were almost entirely dominated by Adriatic vessels. However, inland areas show increasing integration with other extra-provincial economies, particularly those in the Eastern Mediterranean. This reached its greatest extent in the west of south-west of the Po valley, which recorded the lowest quantities of Adriatic goods and saw integration into Western Mediterranean markets, despite the barrier posed by the Apennines. Overall, amphora-borne trade in Northern Italy seems to have been import-orientated, consisting almost entirely of vessels produced outside the valley with strong connections to extra-provincial markets.⁷¹ Strikingly, the only amphora produced for export in Northern Italy seems to have been the Flat-Bottomed Italic form, which saw distribution across the Mediterranean during the second century AD.

6.6 Discussion: The Third-Fifth Centuries AD

Although it is evident that the third-fifth centuries AD saw significant changes to amphora-borne trade in Northern Italy, the lack of published evidence makes it difficult to analyse these changes in detail. From the third century AD onwards, all sites show a complete absence of any Adriatic vessels. The disappearance of

⁶⁹ Van Limbergen (2011), 85-86. See Strabo, 5.4.2 and the *Anthologia Graeca*, 6.257, 9.232, which suggest some styles produced in the area of Picenum were of high quality.

⁷⁰ Brughmans and Poblome (2016a), 402-04; Temin (2013), 13-15.

⁷¹ Cipriano and Mazzocchin (2019), 240-43. The overwhelming majority of Dressel 6A/B vessels identified as having a Northern Italic production by their research were distributed within Northern Italy and Magdalensberg region. The full contribution of Northern Italic Dressel 6A and 6b production remains unknown.

Adriatic amphorae during this time has been noted across the Adriatic littoral, where they are predominantly replaced by Eastern containers.⁷² The Northern Adriatic and Northern Italy show a slightly different pattern, where North African imports gain an equal/greater share of the market than their Eastern counterparts.⁷³

While an absence of Adriatic vessels could indicate a collapse of wine, oil, and fish sauce production in the region, this seems a somewhat simplistic interpretation. It is more probable that the archaeological record reflects a cessation of production of the vessels used to transport them during the first-second centuries AD, with a gradual switch to containers such as barrels and skins during the late second century to early third century.⁷⁴ Unfortunately, the paucity of surviving examples for these containers makes it difficult to establish a chronology for their use within the region, but other evidence points to a rise in their use in Northern Italy from the second century AD onwards. Multiple reliefs depicting the transport of barrels and skins have been recovered from the area around Picenum, the principal production area for amphora-borne wine in the Adriatic. A second century funerary inscription celebrates the life of a cooper at Cupra Marittima, while a third-century relief from Ancona depicts a transaction of barrels of wine (see Figure 6.87).⁷⁵ Two mid-first century AD urns from Firmum also depict the storage and transport of wine in skins.⁷⁶ Furthermore, a collapse of Adriatic oil and wine is not supported by evidence from the production sites themselves. The period of the third-fifth centuries also saw a consolidation of villa estates in the Po plain, especially in the area of modern Lombardy, and recent work by Van Limbergen has demonstrated the continuation of oil production at rural sites along the western coast of the Adriatic into the third-fifth centuries.⁷⁷ The movement of an imperial capital to Milan in the late 280s, and then to Ravenna in 402, alongside the increasing militarisation of the region during the third century, also saw Northern Italy achieve new prominence.⁷⁸ The presence of the court and permanent garrisons created new demand in foodstuffs, and, consequently, the true importance of regional and local trade during this era is probably obscured by the archaeological record.

⁷² Auriemma et al. (2015), 153.

⁷³ Auriemma et al. (2012), 285-90.

⁷⁴ Panella and Tchernia (1994), 159-60. The possibility of locally produced amphora forms during this period that have yet to be identified should also be entertained.

⁷⁵ Paci (2009); Profumo (2005).

⁷⁶ Marengo (2003).

⁷⁷ Brogiolo and Chavarría Arnau (2018), 184-85; Van Limbergen (2018), 77-87. While the area's rural economy seems to have contracted during the second century AD, several oil-pressing sites see repairs or expansion during the subsequent centuries.

⁷⁸ Roncaglia (2018), 119-22.

During the third-fifth centuries AD, North African containers make up a significant share of each assemblage's provenance for the first time. This reflects the rising importance of the North African coast as a production centre from the second century AD onwards, both in amphora-borne goods and other ceramic products.⁷⁹ Western imports entirely disappear except for those from the Iberian Peninsula, possibly reflecting a decline in Gallic and Central Italian viticulture during the third century alongside the networks of exchange used to export them.⁸⁰ Alternatively, the absence of amphorae from these regions may also indicate a switch to barrels as their dominant transport container, making distribution difficult to identify. The Adriatic coast continued to be the dominant entry point for goods coming into the valley, especially given the increased importance of Aquileia and Ravenna during this period.⁸¹ While Eastern and Northern African imports travelled up the Po, the limited data from the west of the study area seems to suggest that trans-Appennine trade remained important during this period. The highest quantities of Iberian amphorae were recovered from Ivrea in the west of the Po valley, with Iberian imports appearing in minimal quantities at sites elsewhere in the region. Unfortunately, without the publication of more assemblages from the western end of the valley, it is difficult to make conclusive judgements on the intensity of trans-Appennine trade during the third-fifth centuries AD.

The majority of assemblages in this period (with the exception of Trento) continued to exhibit a high level of diversity in the vessels they contained. While a limited number of vessel forms originating from the Adriatic had dominated the Late Republic and first-second centuries AD, the third-fifth centuries saw an expansion in the number of vessel types imported from North Africa and the East. Within the broader classification of North African and Eastern, each regional provenance contained a variety of individual production zones, with North African vessels coming from Mauritania Caesariensis (Keay 1A), Tunisia (Spatheion 1), and Tripolitania (Tripolitanian 3), while Eastern vessels originated from the Aegean (LRA 2) and Palestine (Almagro 54).⁸² None of the forms produced in these regions dominated third-fifth centuries AD assemblages in the same way the Lamboglia 2 and the Dressel 6A and 6B had in the Late Republic and first-second centuries AD. Indeed, the main component of each assemblage varied from site to site during this period. The Spatheion 1 dominated the late assemblage at Brescia, yet failed to make the top three forms in Milan. In the

⁷⁹ See Hobson (2015), 63-142 for a summary of the evidence for rising importance of North Africa for oil, wine, and ceramic production in the Imperial period.

⁸⁰ Laubenheimer (1985); Rice (2012), 251-57.

⁸¹ Roncaglia (2018), 136-41.

⁸² Bonifay (2004), 124-29; Karagiorgu (2001), 129-31; Keay (1984), 94-99, 278-85.

same vein, the Almagro 54 was dominant at Verona, yet completely absent from Aquileia. The failure of a single dominant form to arise from either the Eastern Mediterranean or North Africa during this period attests to the variety of production and diversity of vessels available across the Late Antique Mediterranean. Northern Italy was no longer reliant on a single zone of production, with its demand for amphora-borne goods met by a wide range of Mediterranean connections.

The change in provenances and the increased variation amongst the vessel forms during the third-fifth centuries AD strongly suggests that the networks responsible for importing amphorae into Northern Italy had changed significantly from earlier periods. The decline of old trade routes and production areas led to the creation of new supply networks, originating from regions that had previously played a marginal role in the provisioning of the region. The dominance of North African, Eastern, and Iberian vessels demonstrates Northern Italy's continued integration into extra-provincial economies. Although the amphora data alone would suggest the collapse of regional production and trade, changes in containerisation and evidence for wine and oil production suggest this is unlikely.

6.7 Conclusions

Amphora-borne trade in Northern Italy saw continuous evolution over the Roman period, both in the variety and provenance of the commodities the region imported. While the majority of its amphorae originated from within its immediate vicinity, Northern Italy was also integrated into the wider Mediterranean economy, with Eastern, Iberian, and North African imports making important contributions throughout the Roman Period. The provenance of amphora-borne goods would change significantly over the course of the Roman era. The Adriatic would dominate in the Late Republic and first-second centuries AD, with both Western and Eastern Mediterranean imports assuming an increasingly important role in the Imperial period. By the third-fifth centuries AD, North Africa, a previously minor contributor, had gone on to become the principal supplier of amphorae to the region. The overall picture that emerged was of a region with far greater diversity inland as opposed to the coastal regions. The results highlighted the role of both cost and choice in determining import provenance and the sophistication of the networks of transport and exchange within the valley that enabled the circulation of amphora-borne trade. The Adriatic coast would form the principal entry point of imports into Northern Italy throughout the Roman period, but the amphora analysis also demonstrated the important role trans-Appennine

trade played in supplying the west and south-west of the Po valley.

Analysing the spread of different amphora provenances and vessel types produced some surprising results, challenging the perception of inland areas as being disconnected and isolated. While amphorae primarily carried staple goods long distances that formed an essential component of everyday diets, other types of ceramic such as finewares, a non-essential commodity that travelled over short and long distances, offer a valuable comparison to the patterns presented here.

Chapter 7

Finewares

Finewares, alongside amphorae, form one of the most commonly traded artefacts of the Roman period surviving in the archaeological record. The distinctive glossy red veneer of terra sigillata and African Red Slip (ARS) tablewares are instantly recognisable and saw widespread distribution across the Roman World.¹ While their ubiquity makes fineware datasets an obvious choice for analysis, they also provide a valuable point of comparison to amphora-borne trade. Amphorae were primarily traded for their contents, whereas finewares were consumed as a singular product. Furthermore, fine tablewares were a non-essential commodity, and, as such, their patterns of distribution reflect different mechanisms of consumption and exchange to the foodstuffs that formed the most common amphora-borne cargoes.² Additionally, the fact that there was significant production of sigillata within Northern Italy itself (in comparison with the limited amphora production, mainly concentrated in the east of the study area), offers greater insight into networks of local distribution present within the region during this period.

As commonly found artefacts, terra sigillata and ARS have seen intensive study over the past century and, as a result, the chronology of the production and consumption of Roman red-slip tablewares in Italy is well established. Italian terra sigillata began to appear during the late Republic and quickly replaced Black Gloss ceramics, which had previously been the dominant form of tableware in Italy.³ Production is assumed to have begun at Arezzo but quickly expanded

¹ The Covid-19 pandemic prevented access to libraries and material and, as a result, there are some omissions in the fineware analysis where restrictions made it impossible to access published assemblages. In particular, Republican finewares such as Black Gloss ceramics and other, less evenly published finewares, such as Thin-Walled and Invetriata, are not discussed within the chapter.

² Although the term ‘finewares’ suggests a level of expense and exclusivity, fine tablewares achieved a remarkable level of penetration across all social strata. The Roman Peasant Project found evidence for the consumption of finewares at even the lowest sites in the settlement hierarchy (Arnoldus et al. (2021a), 559-61; (2021b), 190-94).

³ Mantovani (2013), 143; Mazzeo Saracino (2000), 38. It is worth highlighting that red-slipped Eastern Sigillata A had already begun to appear in the Eastern Mediterranean by the latter

to include other sites in Central and Northern Italy by the end of the first century BC. This was followed by the establishment of workshops first in Southern, and then Central Gaul, which produced sigillata between the late-first century BC and second century AD.⁴ The development of ARS in the second century AD saw it rise to become the dominant tableware in the Mediterranean from the third century AD into the early Medieval period.⁵ Against this backdrop, other forms of tableware such as Eastern Sigillata and Middle Adriatic Sigillata also circulated in the market, but none achieved the same prominence within Northern Italy as the types mentioned above.

While the development of fineware production and imports in Northern Italy is (reasonably) well-understood at a macro-level, the ways in which finewares entered and were distributed across the region are less so. Numerous hypotheses have been put forward over how finewares circulated within Northern Italy, yet most of these have focused on the regional diffusion of vessels from individual potters or the provenance of sigillata at particular sites.⁶ A region-wide study of quantified fineware assemblages will allow underlying patterns and trends present in the data to be brought to the fore, allowing broader regional questions to be answered.⁷

This chapter uses the assembled red-slipped fineware data from Northern Italy to analyse patterns in the region's trade in finewares between the late-first century BC and the fifth century AD. The results from the analysis are presented, outlining where the majority of fineware imports originated on a site-by-site basis. Areas of Northern Italy that exhibited high diversity in their fineware forms and imports are highlighted, and reasons offered as to why this might have been the case. The resulting patterns are then situated within a chronological and geographical framework, allowing a picture of how the consumption of finewares

half of the second century BC and was circulating in Italy prior to the development of Italian Terra Sigillata (Van Oyen (2016), 13).

⁴ Desbat et al. (1996); Picon and Lasfargues (1974).

⁵ Bonifay (2003); (2004).

⁶ See, for example, Kenrick's (2000) mapping of the distribution of *Sarius* and *Serius* stamps in Northern Italy; Gabucci and Quiri's (2008) discussion on the evolution of ceramic imports to Ivrea in the Early Imperial period. Such an approach has been criticised in the past by those studying sigillata (see Della Porta (1998); Olcese (1999)) who have called for greater integration of data between sites.

⁷ One of the most important of these is the point of entry for Gallic Terra Sigillata into the region, with opposing views over whether it was transported over the Alps or arrived in the region via maritime routes. The principle work advocating a transalpine vector for Gallic Terra Sigillata is *Attraverso le Alpi e lungo il Po: importazione e distribuzione di sigillate galliche nella Cisalpina* (Gabucci (2017)). While a valuable contribution, the work analyses Gallic Terra Sigillata in isolation from other contemporary fineware imports, potentially leading to their prominence at some sites being overstated. Finds of Gallic Terra Sigillata in the east of the region are also engaged with in a limited capacity. See also Donat (2015); (2020); Mantovani (2018).

evolved across Northern Italy to emerge. A final discussion situates the results within wider debates on the mechanics of inland economies during the Roman period. The locations of sites mentioned within this chapter can be viewed in Figure 7.1.

7.1 Fineware Types

The main fineware types discussed in this chapter are: Italian Terra Sigillata (ITS), Gallic Terra Sigillata (GTS), Eastern Sigillata (ES), and African Red Slip ware (ARS). Under the umbrella of ITS are included: Central Italic Sigillata (CITS) produced at Arezzo and other central Italian sites such as Pisa, Northern Italic Sigillata (NITS) produced in Northern Italy, and Middle Adriatic Sigillata (MATS) produced along Italy's eastern Adriatic coast in the late Roman period. While CITS, GTS, ESB, and ARS have been explored in detail elsewhere, NITS and MATS are less well understood and warrant further discussion below.⁸

7.1.1 Northern Italic Terra Sigillata

In contrast to the amphorae discussed in the previous chapter, there is widespread evidence for the production of terra sigillata across Northern Italy from the latter half of the first century BC to the fourth century AD.⁹ It is assumed that sigillata production began in Northern Italy during the last quarter of the first century BC, when workshops that had previously specialised in Black-Gloss ceramics began to emulate red-slip wares originating from Central Italy.¹⁰ The most recent edition of the *Corpus Vasorum Arretinorum* identifies at least 145 potters active in Northern Italy between the mid-first century BC and the late second century AD.¹¹ The greatest concentrations of NITS are found within Northern Italy itself, the Adriatic littoral, and along the Danubian *Limes*, although it also saw wider distribution across the Mediterranean (see Figure 7.2).¹² Despite its widespread circulation, both in Northern Italy and further afield, the production of NITS is far less well-understood than its Arretine and Central Italic counterparts. While there have been repeated calls for additional study and the creation of a research

⁸ For Central Italic Sigillata, see: Ettlinger et al. (1990); Menchelli (2005); Morel (1981); Van Oyen (2015). For Gallic Sigillata, see: Fulford and Durham (2013); Lewit (2015); Mees (2011); Van Oyen (2016). For Eastern Sigillata, see: Bes (2015); Gunneweg et al. (1983); Lund (2003). For ARS, see: Bonifay (2003); (2004); (2018); Fentress et al. (2004); Hayes (1972); Mackensen and Schneider (2002).

⁹ Jorio (1998), 125; Mazzeo Saracino (2000), 33.

¹⁰ Mantovani (2013), 143; Mazzeo Saracino (2000), 38.

¹¹ Oxé et al. (2000).

¹² Brusić (1999); Košćević and Makjanić (1995); Mercado (1972); Mertens (1972); Schindler-Kaudelka (1980).

framework, the most influential scholarship on NITS still dates to the 1990s and early 2000s.¹³

Although a large number of potters are known to have been based in Northern Italy, few production sites have been discovered.¹⁴ Even among kilns that have been located, such as those at Cremona and Padua, there is controversy over whether they were used to produce terra sigillata or other forms of ceramic.¹⁵ Other studies have attempted to distinguish production areas using different methods, with mixed success. Fabric analysis is one such approach, however the geology of the Po valley is so homogenous that it is difficult to distinguish the provenance of a vessel from its fabric alone.¹⁶ Indeed, it can often be difficult to distinguish between sigillata originating from Central Italy and the highest quality sigillata produced in Northern Italy in the absence of stamps or laboratory analysis.¹⁷ Archaeometric analysis, such as Principle Component and Cluster Analysis, have helped to isolate some broad areas of production, although narrowing this down to specific locations continues to be reliant on the discovery of kiln sites.¹⁸

The principal phase of sigillata production in Northern Italy took place between the latter half of the first century BC and the first half of the first century AD. This phase was characterised by the production of high-quality vessels, many of which were indistinguishable from Arretine and Central Italic vessels. In the latter half of the first century AD, the quality of the sigillata being produced in the Po valley began to decline. This later sigillata is sometimes referred to as Sigillata Tardopadana, or alternatively ‘Late Padan Sigillata’ or ‘Late Northern Italic Sigillata’; here referred to as Late NITS. Its production is dated to be-

¹³ Kenrick (2000); Mazzeo Saracino (2000); Olcese (1999).

¹⁴ Kenrick (2000), 47. Some have hypothesised that this is due to most kiln sites being located in urban areas, having been destroyed or buried beneath later structures (Della Porta (1998), 82). Another possible reason may be due to kiln sites having been located on the valley floor close to the watercourses, in which case they may be buried beneath later alluvial deposits, too deep to detect by conventional means (see Section 3.1.4).

¹⁵ Cipriano and Mazzocchin (2010), 141; Della Porta (1998), 83. While some kilns have been discovered, the low incidence of terra sigillata and absence of sigillata wasters amongst the artefacts recovered makes a firm identification difficult. Mantovani ((2013), 143-44) provides a list of possible production sites for Northern Italic Sigillata, which include Adria, Bolonga, Cremona, Faenza, Milan, Mirandola, and Padua. Although Gabucci and Quiri ((2008), 51-52) have also identified several possible sigillata wasters at Ivrea that hint at possible mid-Augustan production at the site, the evidence is somewhat patchy.

¹⁶ Della Porta (1998), 82; Jorio (1999), 84. There have also been attempts to subdivide NITS into separate fabric groups in the same way as Eastern Sigillata and ARS, however this has not seen wide adoption amongst researchers (Zabehlicky Scheffenegger and Sauer (2000)). The existence of distinct productions of NITS was recognised during the Magdalensberg excavations in the 1970s (Schindler and Zabehlicky Scheffenegger (1977)). These were classified as productions A-D. Of the reports used in the present analysis, only the material for Padua (Rossi (2013)) made use of the fabric classifications when referring to its material.

¹⁷ Della Porta (1998), 81; Mazzeo Saracino (2000), 37.

¹⁸ Maritan et al. (2013); Olcese (1999).

tween the late first century AD and the mid-third century AD, although some have argued it was produced into the fourth century.¹⁹ What exactly constitutes Late NITS is often poorly defined. Some studies distinguish between the earlier NITS of the first century BC to mid-first century AD and the Late NITS of the late-first century AD to fourth century AD, while others treat them as a single evolving style of production without drawing a distinction.²⁰ This confusion is compounded by the fact that there is no separate typology for Late NITS. The style typically mimics vessel forms from earlier periods, as well as some ARS vessels forms which begin to appear in the region during the second century.²¹ The forms and decoration of the style also seem to be heavily influenced by Gallic wares, combining applied barbotine decoration and wide brims in a style not seen in previous iterations of NITS.²² Aside from imitating earlier and contemporary vessel forms, Late NITS is characterised by a decline in quality when compared to previous sigillata produced in Northern Italy. This is characterised by the use of poor-quality clay, variable fabric consistency from different firing temperatures, rough textures, and thin, cracked, or blotchy slips.²³ Due to the mixed quality of production, there is very little homogeneity within the style, which can make it hard to identify. Despite this, Late NITS seems to have seen similar distribution to earlier sigillata produced in Northern Italy, principally being traded within the Po-Veneto region and the Danubian provinces.²⁴

7.1.2 Middle Adriatic Terra Sigillata

MATS (or Sigillata Medio-Adriatica as it is otherwise known) is a late form of sigillata produced between the third and fifth centuries AD, first typologised by Luisa Brecciaroli Taborelli during the 1970s.²⁵ The form was mainly produced along the Western Adriatic coast of Italy between Southern Emilia-Romagna and central Marche, and was exported along the Adriatic and Tyrrhenian coasts of Italy.²⁶ Sigillata belonging to the group is characterised by an opaque, reddish-brown slip, which is lighter and a deeper orange in colour than other sigillata produced in Italy.²⁷ In some cases, vessels are additionally decorated with circular

¹⁹ Mazzeo Saracino (2000), 39; Zabehlicky-Scheffenecker (1992), 415.

²⁰ Of the assemblages analysed below, only Aquileia (Donat and Maggi (2017)), Chieri (Vanetti (1987)), Cremona (Amadori (1996)), and Milan (Jorio (1991)) list Sigillata Tardopadana amongst their finewares. The other assemblages treat all Italian material dating from the first, second, and third centuries AD as a single style of sigillata.

²¹ Jorio (1998), 125; Robino (2008), 27.

²² Ettlinger et al. (1990), 50; Mazzeo Saracino (2000), 39.

²³ Jorio (1998), 127.

²⁴ Košćević and Makjanić (1995); Zabehlicky-Scheffenecker (1992).

²⁵ Brecciaroli Taborelli (1978); Stoppioni (2008), 713-4.

²⁶ Biondani (2014), 253; Dal Sie (2018c), 105; Tortorella (1996), 325.

²⁷ Brecciaroli Taborelli (1978).

patterns added in brown paint over the slip.²⁸ It appears in significant quantities within the east of the study area, particularly in the coastal plain and port sites.

7.2 Analysis

Using the parameters described in Chapter 5, a total of twenty-three fineware assemblages from inland urban centres across Northern Italy were compiled for analysis. Five port assemblages were also examined to provide points of contrast: four from the Adriatic seaboard – Altinum, Ariminum, Aquileia, and Ravenna, and one from the Ligurian seaboard – Luna. All sites selected for analysis can be seen in Table 7.1 and are mapped geographically in Figure 7.3.²⁹ The number of sherds within the dataset totalled 8260. Of these, 6494 belonged to the first-second centuries AD, and 1731 to the third-fifth centuries AD (see Figure 7.4). The total number of sherds by site per period can be found in Appendix C. A total of 720 legible stamps were included in the dataset, available in the data supplied by Appendix B.

7.3 Results: Fineware by Period

In a similar manner to the amphora data, the results of the fineware analysis were uneven across the two chronological periods. Fineware data from the first-second centuries AD exhibited several clear patterns, with further underlying trends identified via quantitative analysis. The data from the third-fifth centuries AD was of poorer quality, which hampered its analysis. Substantially fewer sites produced assemblages for this period and those that did often contained a lower quantity of fineware. Despite the challenges presented by the later data, several interesting observations could be made when it was quantitatively analysed.

7.3.1 The First-Second Centuries AD

During the first-second centuries AD, finewares originated from five different zones of production: Central Italy, the Eastern Mediterranean, Gaul, North Africa, and Northern Italy (see Figures 7.5 and 7.6). Northern Italy formed the most common provenance for finewares in the region, accounting for 57% of all vessels during this period and forming the main component of twenty-three out of the twenty-six assemblages. The next most common provenance was Central Italy, with

²⁸ Dal Sie (2018c), 105.

²⁹ The assemblages from Novara and Vercelli only contained the total percentages for each fineware provenance, hence the absence of a total of sherds in Table 7.1.

Site	N. Fragments	N. Stamps	Publication
Acqui Terme	47	3	Robino (2008); (2017)
Adria	153	26	Mantovani (2013)
Alba	230	11	Volonte (1997a)
Altinum	410	3	Dal Sie (2018a); (2018b); (2018c); (2018d) Pagen (2018) Bortolamei and Bottos (2017a); (2017b); (2017c); Donat (2017); Donat and Maggi (2017); Maselli Scotti (2017); Zulini (2017) Angelini (2018)
Aquileia	508	7	Biondani (2005b); (2005c); (2005d) (2005e); (2005f)
Ariminum	151	1	Ratto (2014)
Augusta Bagiennoum	35	21	Baldoni (1986)
Bologna	53	3	Jorio (1999); (2002)
Brescia	874	0	Massa (1999); (2002)
Calvatone	58	1	Volonte (1991); (1997b)
Chieri	402	3	Vanetti (1987)
Cividate Camuno	60	0	Fabbri et al. (2004)
Como	257	1	Butti (2016) Pisano Briani (2016)
Cremona	342	15	Amadori (1996) Cattaneo (1996)
Forlì	187	6	Cipriano (2013)
Ivrea	174	75	Brecciaroli Taborelli (1987b); (1998); Gabucci (2017); Gabucci and Quiri (2008)
Julia Concordia	262	189	Cipriano and Sandrini (2011)
Luna	305	64	Lavizzari Pedrazzini (1973a); (1973b)
Milan	727	33	Jorio (1991); Roffia (1991) Mongardi (2014); Rigato and Mongardi (2017)
Modena	156	146	Spagnolo Garzoli et al. (2008)
Novara	n/a	35	Rossi (2013)
Padua	90	27	Airoldi et al. (2018)
Ravenna	194	2	Gabucci (1995)
Tortona	86	62	Oberosler (1995)
Trento	289	3	Brecciaroli Taborelli and Gabucci (2007)
Turin	1505	0	Spagnolo Garzoli et al. (2008)
Vercelli	n/a	23	Morandini (2008a); (2008b)
Verona	435	0	

Table 7.1: Fineware assemblages analysed in Chapter 7.

sigillata from production areas near Arezzo and the centre of the Italian peninsula supplying 21.5% of finewares between the first and second centuries AD. The third most common provenance was Gaul, accounting for 18% of finewares in the region during this period. The majority of GTS seems to have originated from workshops in Southern Gaul, although several assemblages contained sigillata produced in Central Gaul (see Figure 7.7). Sigillata from the Eastern Mediterranean formed 2.6% of the total number of vessels, while North African finewares constituted <1% of the total.

When sites in the first-second centuries AD dataset were hierarchically clustered using the UPGMA algorithm based on the provenance of their assemblages, three broad geographic clusters were identified (see Figure 7.8 and 7.9). The first cluster contained the majority of sites within the study area and was principally formed of sites located on the valley floor and Adriatic coastal plain. The assemblages in this cluster contained the highest percentages of NTIS in the dataset, ranging from 63.9% to 97.3% of each assemblage. After Northern Italy, sigillata from Central Italy formed the second most prominent group at each site within the cluster, ranging from 28.5% at Brescia to 2% at Adria. There were three subgroups located within the first cluster, based on the percentage of NITS contained within each assemblage. In the first group, the percentage of NITS vessels ranged from 97.3% at Adria to 94.8% at Verona. In the second group, the percentage of NITS vessels ranged from 78% at Vercelli to 83.6% at Calvatone. In the third group, the percentage of NITS vessels ranged from 63.9% at Tortona to 71% at Novara. There was no obvious geographic pattern to these subgroups.

The second cluster was comprised of Bologna and Modena, two adjacent sites along the via Aemilia. Both Bologna and Modena exhibited a near identical provenance for their assemblages, which saw finewares from Central Italy, rather than those from Northern Italy, as the main component. Neither site contained sigillata from a non-Italic provenance, with NITS making up the remainder of each assemblage.

The third cluster contained sites located in the south-west of the study area and those in the western foothills and valleys of the Alps. The sites included in this cluster were defined by a larger than average proportion of GTS in their assemblages, ranging from 16.6% at Milan to 41.1% at Turin. NITS remained the main fineware within these assemblages, the exception being Acqui Terme, for which GTS was the main component, and Augusta Bagiennorum, for which CITS was the main component.

The addition of assemblages from the Adriatic and Ligurian ports to the analysis did not significantly change the clusters. The Adriatic port sites demonstrated a more varied provenance for their assemblages, with Altinum, Aquileia,

and Ariminum returning examples of both ES and ARS, while Ravenna only contained examples of ES. These were not present in sufficient quantities to result in the port sites forming a defined cluster. Instead, the Adriatic ports placed within Cluster 1, their sub-groups reflecting the percentage of NITS in their assemblages (see Figure 7.10). The exception to this was Aquileia, where the high proportion of ES in its assemblage (37.1%) saw it place separately from the other clusters. Quantified fineware data could only be acquired for the port of Luna on the Ligurian Coast. Luna grouped with Bologna and Modena when included in the hierarchical clustering, a result of CITS also forming the main component of its fineware assemblage (see Figure 7.11).

Although the majority of sites in the first-second centuries AD dataset showed little diversity in the provenance of their assemblages, with most finewares being sourced from the same three regions, almost all sites exhibited a high level of diversity of vessel forms. There were 237 unique forms in the first-second centuries AD assemblage (as opposed to sixty-four amphora forms during the same period).³⁰ No single vessel form dominated the region, reflecting the breadth and diversity of tableware available. Few vessel forms accounted for >1% of the total assemblage, exceptions being the forms Dragendorff 32/37 from Northern Italy (3.04%) and Dragendorff 37 from Gaul (2.84%) (see Figures 7.12 and 7.13).³¹ When measured with Simpson's Diversity Index, all but two sites returned a score of over 0.8, suggesting high diversity (see Figure 7.14). The two exceptions were Adria and Cremona, which returned values of 0.68 and 0.6 respectively. While lower than those of the other sites, these values still suggest a high level of diversity in the assemblages. There was no obvious geographic trend in the values, although the Adriatic and Ligurian ports returned some of the highest values for diversity in the dataset, each scoring above 0.92 on the index. Applying the Morisita-Horn Overlap Coefficient to the data saw some sites that were geographic neighbours, such as Augusta Bagiennorum and Tortona, Padua and Julia Concordia, and Cremona and Calvatone, clustered close together; suggesting high levels of overlap in their assemblages (see Figure 7.15). However, beyond this there were no further geographic patterns in vessel diversity. Most sites scored between 0.35 and 0.7 in terms of distance between the assemblages, suggesting wide variation in the level of vessel overlap between sites.

The similarity of terra sigillata stamps between assemblages was compared using the Morisita-Horn Overlap Coefficient. When the different workshops and

³⁰ The number of vessel forms from each provenance was too large to legibly graph within a figure. A breakdown of the vessels present at each site is available in Appendix C.

³¹ For information of the Dragendorff 32/37 and the Dragendorff 27, see: Dragendorff (1895); Ettliger et al. (1990); Mazzeo Saracino (1985).

the number examples attributable to each potter were compared between sites, two clear geographic clusters emerged (see Figure 7.16). Each cluster broadly represented the east and west of the region, suggesting a distinction in the workshops supplying terra sigillata between these two areas (see Figure 7.17). There were no clear geographic sub-groups within these clusters. Aside from the main clusters, one smaller cluster comprised of two sites also formed. This cluster contained the sites of Augusta Bagiennorum and Novara, which can be broadly classed as western sites. Adria, Cremona, and Forlì did not join a cluster, each placing individually and suggesting a high level of dissimilarity in the workshops supplying them and other sites. Indeed, the stamps attested at Adria and Cremona had almost no overlap with those present at any other site. Even within the clusters, there was a high level of variation. Most assemblages scored over 0.5 in terms of distance from other sites, attesting to the high number of workshops active during this period.

When the stamp assemblage was separated by the provenance of the workshops and re-analysed with the Morisita-Horn Overlap Coefficient, the division between the east and west of the region was reinforced. When Northern Italic stamps were analysed, two clear clusters formed, broadly divided into the south-east and north-west of the region (see Figures 7.18 and 7.19). Aquileia, Augusta Bagiennorum, and Forlì placed independently due to each only containing a single Northern Italic stamp in their assemblage. Within the clusters, there remained a high level of dissimilarity between the stamp assemblages, with all but Milan and Ivrea scoring over 0.7. When Central Italic stamps (both Arretine and other Central Italic) were analysed, the sites once again divided into eastern and western clusters, with the cluster containing the two sites of Augusta Bagiennorum and Novara also forming again (see Figures 7.20 and 7.21). Cremona and Forlì did not join a cluster, each placing individually and suggesting a high level of dissimilarity in the workshops supplying them and other sites. Overall, there was a much lower level of dissimilarity between the CITS stamp assemblages when compared to the NITS assemblage. When the Central Italic stamp dataset was further broken down between Arretine and non-Arretine stamps, the overall division between eastern and western sites remained robust (see Figures 7.22 and 7.23). However, western sites showed far greater levels of similarity for stamps with a non-Arretine provenance, while sites in the eastern valley showed greater levels of similarity for stamps with an Arretine provenance. While Arretine and non-Arretine stamps were present at most sites (with Arretine stamps in the greatest quantities), the greater levels of similarity for sites with Arretine stamps in the east of the region and sites with non-Arretine stamps in the west of the region may reflect differing trade networks for CITS in Northern Italy. Unfor-

tunately, there were not enough Central Gallic, South Gallic, or Eastern stamps within the dataset to perform more detailed analysis.

In summary, the trade in finewares within Northern Italy during the first-second centuries AD was primarily dominated by sigillata produced in the region. Other provenances were also present, and while they formed less than 45% of the total finewares transported, these vessels were not evenly distributed across Northern Italy. Although assemblages in the coastal hinterland and Po valley were mainly composed of NITS, sites in the far west of the region and those in the Alpine foothills saw imports of GTS take up a greater portion of their assemblage. Several sites along the line of the via Aemilia also saw CITS, as opposed to NITS, make up the majority of their assemblage during this period. There was a high level of diversity in the vessel composition of each site's assemblage with many showing a high level of dissimilarity to others in the study area, suggesting a wide variety of fineware forms being traded during this period. The stamp data suggests that, while the products of some workshops were widely exported across the region, some potters may have primarily traded in the eastern or western sections of the Po valley.

7.3.2 The Third-Fifth Centuries AD

Moving into the third-fifth centuries AD, only five of the twenty-one inland fineware assemblages exceeded the threshold of thirty sherds of ceramic necessary for analysis. During this period, finewares originated from five different zones of production: the Middle Adriatic, the Eastern Mediterranean, Gaul, North Africa, and Northern Italy (see Figures 7.24 and 7.25). North Africa formed the most common provenance for finewares in the region, accounting for 66.9% of all vessels during this period and the main component in five of the eight assemblages analysed. MATS made up 17% of the total third-fifth centuries AD assemblage. MATS was located in the greatest quantities in the south-east coastal region of the study area, closest to where it was produced (at Ariminum and Forlì it comprised between 75.2% and 90.7% of the third-fifth centuries AD assemblages respectively). Although mainly located in coastal sites, MATS appeared in surprising quantities further inland (for example, at Verona it made up 11.3% of the third-fifth centuries AD assemblage). NITS accounted for 15.7% of the total third-fifth centuries AD assemblage. Recovered from four sites, it made up between 1% at Milan and 83.6% at Alba of Late Antique assemblages. ES and GTS each comprised <1% of the total third-fifth centuries AD assemblage, with only three fragments of fineware attributed to each provenance.

When sites in the third-fifth centuries AD dataset were hierarchically clustered

using the UPGMA algorithm based on the provenance of their assemblages, a single cluster of three sites formed, consisting of the assemblages with the highest percentages of North African finewares (see Figure 7.26). These were Brescia, Milan, and Verona, with quantities of North African material ranging from 67.6% to 96.4% of each assemblage. Alba and Forlì did not join this cluster, instead placing individually. At Alba, this was a reflection of the high quantity of Northern Italic fineware present in its third-fifth centuries AD assemblages (83.6%), while Forlì's assemblage was predominantly composed of vessels with an Adriatic provenance (90.7%). The addition of assemblages from the Adriatic ports to the analysis did not significantly change the clusters (see Figure 7.27).³² Although their assemblages contained a much greater proportion of finewares with a Middle Adriatic provenance than most inland sites, ARS remained the main component at Altinum and Aquileia (91.9% and 72.7% respectively). As a result, they joined the cluster of sites dominated by North African material. Ariminum, with its high percentage of Middle Adriatic sigillata (75.2%), grouped with Forlì to form a new cluster. Alba remained independent of either cluster.

In terms of the vessel forms and types present in the third-fifth centuries AD, 131 fineware forms were dated to this period. ARS formed the dominant fineware, particularly fabrics C and D (see Figure 7.28). As with the previous period, most fineware forms comprised <1% of the total assemblage. Two forms were present in significantly higher quantities. The form Hayes 50 accounted for 15.5% of the total assemblage, while the Hayes 61B accounted for 9.9% (see Figures 7.29 and 7.30).³³ The only non-African vessel forms to appear in quantities >1% were the Brecciaroli Taborelli 19/22 (1.3%) and the Brecciaroli Taborelli 15/17 (1.1%), both of a Middle Adriatic provenance (see Figures 7.31 and 7.32).³⁴ Assemblages from the third-fifth centuries AD exhibited a similar level of diversity to their first-second centuries AD counterparts. When measured with Simpson's Diversity Index, scores ranged from 0.87 at Milan to 0.46 at Verona (see Figure 7.33). Sites furthest inland returned the highest diversity scores, with those closest to the coast (Forlì and Verona) returning scores of under 0.76. The Adriatic port sites continued to exhibit high diversity in vessel forms during this period. All port sites returned a value of above 0.91, with Aquileia recording the highest score, 0.96. When analysed with the Morisita-Horn Overlap Coefficient, no new patterns emerged in the data (see Figure 7.34). Some sites geographically adjacent to each other, such as Ariminum and Forlì, continued to group together, as did the ports

³² Unfortunately, no quantified fineware data could be obtained from the Ligurian Coast for the third-fifth centuries AD. Data for this period was also absent from Ravenna's assemblage.

³³ For information on the Hayes 50 and Hayes 61B, see Hayes (1972).

³⁴ For information on the Brecciaroli Taborelli 19/22 and 17/15, see Brecciaroli Taborelli (1978).

of Altinum and Aquileia. Most sites scored over 0.6 in terms of distance from other assemblages, an increase in diversity from the previous period.

In summary, the trade in finewares within Northern Italy during the third-fifth centuries AD was primarily dominated by ARS. Although other provenances were also present, they formed less than 32% of the total finewares transported during this period. Vessels with a Middle Adriatic provenance were mainly located in the eastern coastal regions of the study area, whereas vessels with a Northern Italic provenance were located at peripheral sites such as Alba, Brescia and Verona. Inland assemblages retained a high level of diversity in the vessel composition of each site's assemblage, as did the Adriatic ports. Overlap between assemblages decreased, with sites showing a higher level of dissimilarity in the vessel composition of their assemblages when compared to the first-second centuries AD.

7.4 Results: Finewares by Century

When the finewares dataset was examined on a century-by-century basis, a more complex picture emerged. In most cases, examining the data at a finer chronological resolution served to obscure overarching trends and made it difficult to observe any meaningful patterns. This was especially true for the assemblages from the Augustan period and from the second century AD onwards, which contained significantly less material than the first century AD assemblage (see Figure 7.35). So great was the dearth of material securely dated to a single century between the second-fifth centuries AD, that the threshold for inclusion in the analysis was reduced from thirty to ten sherds per site. The exclusion of vessels that could not be securely dated to a single century and the low quantity of material from these later periods hampered the data's interpretation, especially when it came to using Simpson's Index to examine assemblage diversity. Regardless, some interesting observations could be made. The quantity of each site's assemblage, separated by period, is visible in Table 7.2

7.4.1 The Augustan Period

Eight inland sites returned data for the Augustan period. During this era, finewares originated from four different zones of production: Central Italy, the Eastern Mediterranean, Gaul, and Northern Italy. NITS accounted for the majority of finewares during this period and formed the main component in seven out of the eight assemblages (see Figures 7.36 and 7.37). It was, however, absent from Brescia's assemblage, which was entirely composed of CITS. CITS formed

Site	N. Fragments Augustan period	N. Fragments 1st Cent. AD	N. Fragments 2nd Cent. AD	N. Fragments 3rd Cent. AD	N. Fragments 4th Cent. AD	N. Fragments 5th Cent. AD
Adria	115	38	-	-	-	-
Alba	-	96	17	29	10	-
Altinum	14	239	34	34	69	-
Aquileia	-	57	237	109	58	-
Ariminum	-	24	-	26	-	-
Augusta	-	17	-	-	-	-
Bagiennorum	-	17	-	-	-	-
Bologna	-	18	-	-	-	-
Brescia	13	59	-	134	323	205
Calvatone	-	38	-	-	-	-
Chieri	-	322	80	-	-	-
Como	12	73	38	-	-	-
Cremona	-	169	137	-	-	-
Forlì	-	86	-	88	-	-
Ivrea	26	58	-	-	-	-
Julia	-	148	-	-	-	-
Concordia	19	148	-	-	-	-
Luna	25	174	-	-	-	-
Milan	122	218	13	11	64	18
Modena	22	120	-	-	-	-
Novara	-	n/a	-	-	-	-
Padua	-	72	-	-	-	-
Ravenna	-	176	-	-	-	-
Tortona	-	77	-	-	-	-
Trento	27	225	-	-	-	-
Turin	-	1507	-	-	-	-
Vercelli	-	n/a	-	-	-	-
Verona	-	14	103	90	189	22

Table 7.2: Fineware assemblages separated by period.

the main secondary component in the seven of the eight inland assemblages.

When sites in the Augustan dataset were hierarchically clustered using the UPGMA algorithm based on the provenance of their assemblages a single main cluster formed (see Figure 7.38). This cluster contained two sub-groups, reflecting the varying levels of NITS present within each site's assemblage. There was no obvious geographic pattern to the sites in either sub-group. Adria did not join either of the two sub-groups within the cluster due to the higher quantity of NITS present in its assemblage (96.5%). Brescia placed independently of the cluster as the composition of its assemblage was entirely different to other sites within the Augustan dataset. The addition of the Adriatic port of Altinum and the Ligurian port of Luna did not change this pattern (see Figures 7.39 and 7.40).

When the diversity of each assemblage was measured with Simpson's Diversity Index, scores ranged from 0.87 at Altinum to 0.53 at Modena (see Figure 7.41). All sites scored over 0.5 on the Index, suggesting greater diversity than homogeneity in their assemblage composition. When the contents of each assemblage were compared using the Morisita-Horn Overlap Coefficient, sites within the Alpine foothills (Brescia, Como, Milan, and Trento) had high levels of overlap in vessel types (see Figure 7.42). All sites showed a very low level of overlap in the vessels making up their assemblage, with the majority scoring over 0.75 in terms of distance from other assemblages. Aside from this, no observable geographic patterns emerged in the data.

7.4.2 The First Century AD

Twenty-one inland sites returned data for the first century AD. During the first century AD, finewares originated from five different zones of production: Central Italy, the Eastern Mediterranean, Gaul, North Africa, and Northern Italy (see Figures 7.43 and 7.44). NITS continued to account for the majority of finewares during this period and formed the main component in fourteen out of the twenty-one assemblages. CITS formed the main component in six of the assemblages, while GTS formed the main component of Chieri's assemblage.

When sites in the first century AD dataset were hierarchically clustered using the UPGMA algorithm based on the provenance of their assemblages, three clusters formed (see Figure 7.45). These clusters were formed on the provenance of the main component in each assemblage, with the first cluster of nine sites reflecting assemblages where sigillata of a non-Northern Italian origin comprised at least 42% of the material. The cluster of eleven sites reflected assemblages where NITS comprised at least 66% of the material. There was no observable geographic pattern to either of these clusters. The sites containing the highest levels of GTS (Turin, Chieri, and Ivrea) formed a final cluster in the west of the valley. The addition of the Adriatic ports and the Ligurian port of Luna did not change this pattern, although both Aquileia and Luna placed independently of either cluster (see Figures 7.46 and 7.47).

When the diversity of each assemblage was measured with Simpson's Diversity Index, scores ranged from 0.96 at Ivrea to 0.72 at Adria (see Figure 7.48). All but two sites scored over 0.75 on the Index, suggesting a very high level of diversity in their assemblages, with all sites scoring over 0.70. The Index score for all sites increased from the Augustan period to the first century AD, reflecting the greater diversity in finewares available during this era. When the contents of each assemblage were compared using the Morisita-Horn Overlap Coefficient, no new patterns emerged in the data (see Figure 7.49). The Adriatic ports of Aquileia, Ariminum, and Ravenna formed a single sub-group, alongside the sites of Julia Concordia and Padua on the coastal plain. This suggests a high level of similarity in vessel assemblages in the east of the study area during this period. Altinum placed independently.

7.4.3 The Second Century AD

From the second century AD onwards, the number of sites in each century's total assemblage was severely reduced. As a result, the patterns and trends identified in these centuries are more tenuous than those in the preceding period.

Six inland sites returned data for the second century AD: Alba, Chieri, Como,

Cremona, Milan, and Verona. During the second century AD, finewares originated from four different zones of production: the Eastern Mediterranean, Gaul, North Africa, and Northern Italy (see Figures 7.50 and 7.51). NITS once again accounted for the majority of finewares during this period and formed the main component of each inland assemblage. NITS accounted for 100% of Cremona, Chieri, and Verona's assemblages, while GTS and ARS formed the main secondary components at other inland sites.

When sites in the second century AD dataset were hierarchically clustered using the UPGMA algorithm based on the provenance of their assemblages, two clusters formed (see Figure 7.52). Cremona, Como, and Verona clustered together due to the entirety of their assemblages being composed of NITS. The remaining sites formed the second cluster. There was no obvious geographic distribution to the sites in either cluster. The addition of the Adriatic ports saw them place independently of either cluster (see Figure 7.53).³⁵

When the diversity of each assemblage was measured with Simpson's Diversity Index, scores ranged from 0.90 at Aquileia to 0.47 at Alba (see Figure 7.54).³⁶ Most sites scored over 0.5, continuing to suggest greater diversity than homogeneity in the assemblages. When the contents of each assemblage were compared using the Morisita-Horn Overlap Coefficient, the Adriatic ports and inland sites formed two separate clusters, suggesting less overlap between coastal and inland sites (see Figure 7.55).

7.4.4 The Third Century AD

Five inland sites returned data for the third century AD: Alba, Brescia, Forlì, Milan, and Verona. During the third century AD, finewares originated from five different zones of production: the Middle Adriatic, the Eastern Mediterranean, Gaul, North Africa, and Northern Italy (see Figures 7.56 and 7.57). Finewares from Northern Italy continued to make up the majority of material in this period and formed the main component in three out of the five assemblages. North African finewares formed the main component in Milan's assemblage and Middle Adriatic finewares formed the main component of Forlì's assemblage. There was no single dominant provenance for the assemblages' secondary components.

When sites in the third century AD dataset were hierarchically clustered using the UPGMA algorithm based on the provenance of their assemblages, two clusters formed (see Figure 7.58). These clusters were based on the provenance of the main component in each assemblage, with the first cluster of five sites

³⁵ Unfortunately, no quantified fineware data could be obtained from the Ligurian Coast for the second century AD onwards. These data were also absent from Ravenna's assemblage.

³⁶ Cremona and Verona were excluded as their assemblages contained only a single vessel form.

primarily comprised of North African finewares. The second cluster of three sites consisted of assemblages where finewares of a Northern Italic provenance were the main component. There was no obvious geographic pattern to the sites in the clusters. The addition of the Adriatic ports did not significantly change this pattern; although both Aquileia and Ariminum formed a new cluster based on the high percentage of Middle Adriatic sigillata present at each site (see Figure 7.59).

When the diversity of each assemblage was measured with Simpson's Diversity Index, scores ranged from 0.93 at Aquileia to 0.30 at Brescia (see Figure 7.60). Although most sites still scored above 0.5 on the Index, suggesting greater diversity than uniformity, overall scores were lower in this period. Only Aquileia, Milan, and Ariminum scored higher than 0.75. When the contents of each assemblage were compared using the Morisita-Horn Overlap Coefficient, no obvious geographic patterns were visible in the data (see Figure 7.61).

7.4.5 The Fourth Century AD

Four inland sites returned data for the fourth century AD: Alba, Brescia, Milan, and Verona. During the fourth century AD, finewares originated from three different zones of production: the Middle Adriatic, North Africa, and Northern Italy (see Figure 7.62 and 7.63). Finewares with a North African provenance accounted for the majority of material in this period, forming the main component in three out of the four assemblages and accounting for 100% of the assemblages of Milan and Verona. NITS formed the main component of Alba's assemblage.

When sites in the fourth century AD dataset were hierarchically clustered using the UPGMA algorithm based on the provenance of their assemblages, a single cluster formed (see Figure 7.64). This contained the sites dominated North African finewares. Alba, with its primarily Northern Italic assemblage, placed independently. The addition of the Adriatic ports did not significantly change this pattern; although Ariminum also placed independently based on the high percentage of MATS present within its assemblage (see Figure 7.65).

When the diversity of each assemblage was measured with Simpson's Diversity Index, scores ranged from 0.92 at Aquileia to 0.22 at Verona (see Figure 7.66). A similar level of score variation to that seen in the third century was present, although most sites continued to score over 0.5 on the Index, suggesting greater diversity in their assemblages. The Adriatic ports and Milan remained amongst the sites with the greatest diversity. When the contents of each assemblage were compared using the Morisita-Horn Overlap Coefficient, no obvious geographic patterns were visible in the data (see Figure 7.67). All sites scored above 0.5,

suggesting overall lower levels of overlap between assemblages compared to earlier periods.

7.4.6 The Fifth Century AD

Three inland sites returned data for the fifth century AD: Brescia, Milan, and Verona. During the fifth century AD, finewares originated from a single zone of production: North Africa (see Figures 7.68 and 7.69), with ARS accounting for 100% of the material in this period. As all sites shared the same provenance, they could not be hierarchically clustered. No port returned more than ten sherds of fineware datable to the fifth century AD.

When the diversity of each assemblage was measured with Simpson's Diversity Index, scores ranged from 0.8 at Milan and Verona to 0.35 at Brescia (see Figure 7.70). Most sites continued to score over 0.5 on the Index, suggesting greater diversity in their assemblages. When the contents of each assemblage were compared using the Morisita-Horn Overlap Coefficient, no obvious geographic patterns were visible in the data (see Figure 7.71). All sites showed a very low level of overlap in the vessels making up their assemblage, with the majority scoring over 0.75 in terms of distance from other assemblages.

7.5 Discussion: The First-Second Centuries AD

First-second centuries AD fineware assemblages contained a wide range of ceramic forms, with the first century AD marking a high point in the diversity of vessels within the region. No single vessel type dominated the first-second centuries AD dataset, reflecting the many varied styles and forms of sigillata available during this period. In comparison to the amphorae, which saw a clear increase in assemblage diversity as distance from the Adriatic coast increased, there was no obvious geographic pattern in the diversity of the inland fineware assemblages when analysed with Simpson's Index or the Morisita-Horn Overlap Coefficient. This is perhaps to be expected, given that the majority of inland assemblages primarily originated within Northern Italy and were composed of similar vessel types. Furthermore, the large overlap in the vessel forms produced in Northern and Central Italy resulted in little discernible difference in the types of vessels present in each assemblage, regardless of provenance. This resulted in high levels of similarity between the vessels present in each assemblage, especially in the Augustan period and first century AD. Mirroring the amphora data, the Adriatic port sites had some of the most diverse assemblages within the dataset, likely a reflection of the small quantities of both ARS and ESB present in these

assemblages (with the exception of Ravenna, which only returned ARS).

7.5.1 Northern Italic Terra Sigillata and Short-Distance Trade

One of the most striking results from the finewares analysis, especially in comparison to the amphora data, was the prominence of sigillata produced within the region amongst the assemblages. Potters in Northern Italy seem to have enjoyed a fair degree of regional and extra-regional success, with NITS dominating fineware assemblages across Northern Italy during the first and second centuries AD.³⁷ Even during the Augustan period, at a time when many Northern Italic workshops were making the transition from Black Gloss pottery to red-slipped sigillata, NITS formed the main component of the majority of the assemblages. It is perhaps unsurprising that sites in Northern Italy predominantly consumed fineware produced within the region. Vessels were of a comparable, if not equal quality, to imports of CITS, which would also have travelled much further and accumulated additional costs. Sites in the centre and east of the region, close to possible production sites such as Adria, Bologna, Cremona, Faenza, Milan, Mirandola, and Padua, seem to have returned the highest quantities of NITS in their assemblages.³⁸

Although helpful for highlighting broad geographic trends, NITS is not a particularly useful definition of provenance, considering the geographic extent of the area. A pot produced in the hinterland of Aquileia found at Turin, for example, may have travelled just as far as one produced in Arezzo or in Southern Gaul. Unfortunately, in the absence of confirmed production sites, it is impossible to attribute a more accurate provenance for Northern Italic vessels, frustrating attempts at more nuanced interpretations of short-distance trade in the region. Looking at the stamp data can be of some help in this regard, for example, plotting the distribution of a workshop's stamps may give some indication of where its finewares were consumed.³⁹ However, distribution maps can only reveal so much about wider regional trends. When the assemblages of Northern Italic stamps present at sites in Northern Italy were compared using the Morisita-Horn Overlap Coefficient, the results suggested a clear distinction between the workshops represented in eastern and western sites. Sites that were geographically closer together had greater similarity in their stamp assemblages. Furthermore,

³⁷ Brusić (1999); Košćević and Makjanić (1995); Mercado (1972); Mertens (1972); Schindler-Kaudelka (1980).

³⁸ Mantovani (2013), 143-44.

³⁹ For examples including NITS workshops, see Annibaletto et al. (2007); Buora (2001); Kajanto (1982); Kenrick (2000).

there was very little overlap in the Northern Italic stamps present in the east and the west of the region, especially in comparison to the Central Italic stamps, many of which (for example from the workshops of Ateius and C. Murrius) were present at both eastern and western sites.

The division between the east and west of the region suggested by the stamp data raises interesting questions over how finewares moved within Northern Italy. River transport, as suggested by the network model, was a more cost-effective way of moving cargo long-distances, even when considering transshipment costs. However, the geographic division revealed by the stamp analysis suggests that there was not significant east-west movement (and vice-versa) of NITS. Adria and Cremona, the two centres directly on the Po in the eastern valley, routinely clustered independently from other sites based on the provenance of their assemblages and the stamps contained within them.⁴⁰ While both sites returned a high score for the diversity of their assemblages on Simpson's Index, the provenance of their finewares was limited. NITS, returning some of the highest levels in the study area, dominated both sites. The absence of other finewares from Adria and Cremona does not suggest that the Po (or the wider water network) was a major transport artery for imported finewares during this period. The greater similarity in stamp assemblages from geographically adjacent sites suggests that NITS moved over short distances within Northern Italy and was consumed close to its point of production. To reach local markets, NITS probably travelled overland as a singular cargo.⁴¹ The limited work on tracing stamp distribution further indicates the importance of road over water transport for short-distance trade, with the *via Aemilia* and *via Popila* forming the main transport routes for the finewares of Sarius, Serius, and A. Terentius (see Figure 7.72).⁴²

7.5.2 Central Italic Sigillata: Desirability and Choice

Although many of the assemblages in central and eastern Northern Italy were dominated by NITS, two sites bucked this trend. The cities of Bologna and Modena returned high levels of CITS within their assemblages, forming a separate cluster of two sites. Unfortunately, the limited number of sites with quantified assemblages along the *via Aemilia* makes it difficult to determine whether Bologna

⁴⁰ Although when analysed with solely Northern Italic stamps using the Morisita-Horn Overlap Coefficient, Adria and Cremona clustered with other eastern sites.

⁴¹ Given the inland location of potential production sites, cargoes of NITS would have likely needed to travel overland for at least some of their journey before being transhipped onto a fluvial or maritime vessel if they were destined for further afield. It is, however, possible that overland transport may have been preferable to fluvial regardless, especially considering the high risk of breakages involved with each transfer of cargo. See Harris (2000), 716; Lewit (2015), 240; and Middleton (1980) for discussions of overland vs. fluvial distribution.

⁴² Kenrick (2000), 49-51.

and Modena are part of a wider trend of sites along the road and adjacent to the Apennines returning high quantities of CITS or whether their situation is unique. Indeed, Northern Italy formed the main provenance of finewares in the other two assemblages from cities located on the via Aemilia: Ariminum and Forlì. However, although NITS formed the main component at Ariminum and Forlì, both assemblages returned some of the largest quantities of CITS in central and eastern Northern Italy (32.7% and 27.7% respectively), suggesting stronger links to Central Italic workshops than other sites within their cluster.

From production centres in Arezzo and elsewhere in Central Italy, CITS would have probably travelled overland and crossed the Apennine passes to reach markets in central and eastern Northern Italy.⁴³ The link between Arezzo and the eastern Po valley is demonstrated by the high presence of stamps from Arretine workshops, and their overlap between sites. The network model examined in Chapter 4 suggested that a trans-Apennine crossing would have been an expensive endeavour in terms of transport costs (not taking into account the additional overland transport cost from their original production site to the foot of the pass). The costs accumulated by crossing the Apennines may have reduced the competitiveness of CITS with locally produced NITS in the Po valley, and may account for the drop-off in the quantity of Central Italic finewares recovered from assemblages across the rest of the region. Furthermore, if Bologna and Modena were located at the end of major trans-Apennine transport routes for CITS and served as its initial point of redistribution, the sheer quantity of CITS passing through these sites may have served to reduce the market for Northern Italic finewares.⁴⁴

Of course, transport costs may not have been the only factor affecting the distribution of finewares in Northern Italy. Although they never exceeded 50% of an assemblage outside of Bologna and Modena, CITS still appeared in significant quantities across the region into the late first century AD, despite the ready availability of locally produced vessels. Consumer choice may have played a role here, with CITS deliberately chosen despite its higher cost. The desirability of Arretine sigillata is reflected by several Northern Italic vessels at Ivrea stamped with the word *ARRET[IUM]*, possibly in an attempt to pass off their origin as Arretine or exposit their comparable quality.⁴⁵ Trade connections between workshops in Central Italy and Northern Italy also pre-dated the foundation of Northern Italic workshops. Established connections between Northern Italic consumers and Central Italic producers may have allowed them to better weather

⁴³ Morisani (2014), 161-62.

⁴⁴ The prominence of NITS at Ariminum and Forlì may suggest that the via Flaminia was not the main route via which CITS entered the region.

⁴⁵ Gabucci and Quiri (2008), 51. See also Jorio (2000), 102-06.

new competition from local finewares.⁴⁶ By the second century AD, CITS had completely disappeared from Northern Italy, reflecting the decline of the Central Italic workshops during this period.⁴⁷

7.5.3 Gallic Terra Sigillata and Trans-Alpine Trade

One of the most interesting patterns in the hierarchical clustering analysis related to the trade in GTS within Northern Italy. Sites in the far west of the Po valley, such as Turin, Chieri, and Ivrea, clustered together as a result of the high quantity of GTS within their assemblages (between 17% and 41%). This cluster further extended along the Alpine foothills and into the Alpine valleys along the northern edge of the Po plain, with sites such as Como and Cividate Camuno also returning significant quantities of GTS. The pattern is further supported by the limited data from Aosta, which suggests GTS made up approximately 39% of fineware assemblages in the city during the first-second centuries AD (see Figure 7.73).⁴⁸ The site of Trento forms an exception to this distribution; returning no evidence of GTS in its assemblage despite being located within the Alpine valleys.⁴⁹

Beyond the western reaches of the Po valley and the Alpine foothills, GTS seems to have had low penetration into the central and eastern valley, where it is present in very small quantities (generally <5% of the assemblage). In some cases, such as at Adria, Bologna, Modena, and Verona, it is entirely absent. Given the limited quantities in east Northern Italy, it seems unlikely that GTS was entering the region through the Adriatic ports.⁵⁰ Equally, the lack of GTS present at Luna suggests that the Ligurian ports were not the main entry point.⁵¹ Consequently, the most likely routes via which GTS was transported were over

⁴⁶ There is also the possibility that distribution was linked to military deployments, with Central Italic workshops contracted to supply the army with vessels (Menchelli and Sangriso (2017); Sternini (2019), 493).

⁴⁷ Ettliger et al. (1990), 5-8.

⁴⁸ Gabucci (2017), 4.6. The Aostan data presented here was not included in the main analysis as it failed to distinguish between a Central Italic and Northern Italic provenance for Italic sigillata.

⁴⁹ The absence of GTS from the Trento assemblage is unusual, especially considering that it has been recovered in significant quantities from sites within the city's hinterland (Oberosler (1995), 324-26). It is possible that, in the absence of stamp data or archaeometric analysis, some GTS was misidentified as coming from an alternate provenance in Trento's assemblage.

⁵⁰ GTS is also mostly absent from the wider Adriatic area. See Dannell and Mees (2013) for distribution maps of GTS in the Roman world.

⁵¹ In the past, Liguria has been put forward as the main entry point for GTS into the Po valley (Lavizzari Pedrazzini (2003)). The absence of other coastal assemblages in the dataset makes it difficult to know if Luna is reflective of wider trends on the Ligurian seaboard. However, the low quantity of GTS recovered from Tortona (8.1% of the assemblage), a site on the via Postumia and the main overland route from Genoa and Savona into the Po valley, further suggests that the Ligurian ports were not the main entry point.

the Alpine passes.⁵² Although transporting loads of finewares, not just overland but also over the steep gradients of the Alpine roads, would have carried with it numerous risks, it may not have been as prohibitively expensive as has been often assumed. The results of the network model examined in Chapter 4 suggest that it could have been just as expensive to transport a one tonne cargo to Aosta from the upper Rhône valley as it would have been to transport it from the upper Po valley (see Section 4.5.1). The steep and mountainous terrain of the Alps would have been most suited to pack animals (such as mules and donkeys) carrying loads in paniers, as opposed to wagons.⁵³ It is estimated pack animals could carry loads of between 80 kg and 150 kg, which would have been sufficient for moving finewares in significant quantities.⁵⁴ The chances of breakages would also probably have been reduced via the use of pack animals, their cargo not at the mercy of a wagon's suspension and the road surface.

The quantities of GTS present in the western Po valley and Alpine foothills seem indicative of sustained trans-alpine trade, rather than one-off imports. Conversely, the marginal quantities of GTS in the eastern Po valley and Veneto plain may reflect more sporadic purchases, or relate to the movement of people.⁵⁵ For example, the homogeneity of the assemblage of GTS found at Brescia suggests that it was bought as a single lot, rather than accumulated over time.⁵⁶ In a similar manner to the CITS discussed above, mounting transport costs may help account for the sudden drop-off in the quantity of GTS recovered from the centre of the valley, where it seems unlikely GTS was able to compete with locally produced ceramics (that would have travelled much shorter distances).⁵⁷ In addition, NITS produced in the east of Northern Italy may have accumulated significant transport costs by the time it reached the western valley, especially if it had trav-

⁵² Artru (2016), 109-43; Donat (2015), 42-43; Gabucci (2017), 11.20; Mantovani (2018), 180-81.

⁵³ Pack animals were probably the most common way of transporting goods in the Roman period (Adams (2007); Chevallier (1976)).

⁵⁴ Adams (2007); 77-81; (2012), 230; Raepsaet (2009).

⁵⁵ Gabucci ((2017), 11.22) has argued that the Po formed a major trade corridor for GTS from the west to the east of the region, however, the small quantities recovered from sites in the eastern Po valley and coastal plain point against large-scale organised trade. GTS is certainly present in contexts further east than Northern Italy. The Danubian *Limes* were an important market for sigillata produced in Southern and Central Gaul at centres, such as Bassanac, Le Graufesenque, and Lezoux, and later German centres such as Rheinzabern (Lewit (2015), 230; Leleković (2018); Radbauer (2013), 152-4). Whether their sigillata was transported via maritime routes to Aquileia and into Pannonia, or utilised the Rhône valley to reach the Danube, both methods would have bypassed the Po valley (Dannell and Mees (2013); Donat (2020); Gabler (1986), 51).

⁵⁶ Gabucci (2017), 9.11. Gabucci examines the GTS from a wide range of assemblages (both published and unpublished) from a variety of urban and rural sites within the eastern Po valley and Veneto plain. Where quantification was available, rural sites also returned very low quantities of sigillata from their assemblages. See also, Donat (2015); (2020).

⁵⁷ The drop-off in the quantity of GTS was far more abrupt than that seen for CITS in the central and eastern valley, perhaps suggesting a sudden jump in price.

elled solely overland. This may have helped to reduce its competitiveness (based on price), resulting in buyers consuming sigillata from more diverse origins. It warrants mentioning, however, that even though GTS was able to compete with locally produced ceramics in some parts of the region, it never comprised more than 41% of an assemblage. Furthermore, GTS would only form the main component at one of the nine sites in the cluster, with NITS remaining the dominant fineware in seven out of the nine sites. The uncertain dating given for much of the GTS discussed here means that more nuanced chronological patterns within the first-second centuries AD are difficult to identify.⁵⁸

In addition to the high level of GTS present in their assemblages, many sites within the cluster also returned significant quantities of CITS. There were some of the highest levels seen aside from Bologna and Modena, with CITS comprising more than 30% of the assemblages at Alba and Augusta Bagiennorum. CITS, especially from Arezzo and Pisa, would have been well placed to take advantage of fluvial and maritime connections to transport their wares along the Tyrrhenian and Ligurian coasts. Sites in the western valley (Alba, Augusta Bagiennorum, Novara, and Tortona) returned the highest quantities of stamps from Non-Arretine workshops, although Arretine potters continued to be the best represented. Maritime and fluvial journeys may have served to help reduce transport costs accumulated before crossing the Apennines. Stamps from Non-Arretine potters producing on the Ligurian coast at sites such as Livorno, Pisa, and the Isola di Migliarino are well attested in the western Po valley.⁵⁹ Cities in the western valley such as Alba, Augusta Bagiennorum, and Tortona, close to the Ligurian ports and the trans-Apennine route of the *via Postumia*, were well positioned to take advantage of ceramic trade networks along the Ligurian and Tyrrhenian coasts.⁶⁰ The position of sites in the western valley meant that CITS, GTS, and (in some cases) NITS, had to travel similar distances to reach them. It is possible that transport costs between the three provenances began to even out, resulting in the more equal division between NITS, CITS, and GTS seen in the assemblages at sites such as Alba, Augusta Bagiennorum, and Chieri. Indeed, the network model analysed in Chapter 4 suggested that this area of Northern Italy had could be reached for a similar cost from both the Adriatic and Ligurian coasts (see Section 4.7).

⁵⁸ In particular, it would have been interesting to observe how the decline of Central Italic workshops and the continued production at Gallic workshops from the first to second century AD affected the make-up of fineware assemblages in the western valley. See Gabucci (2017), Chapter 2 for a chronology of GTS production.

⁵⁹ For example, the workshops of Euhodus, L. Rasinus Pisanus, Xanthus, and Zoilus. See Sternini (2019), 485-90 for a summary of CTS production centres.

⁶⁰ Bruno (1998); Filippi (1995); Melli and Pasquinucci (1998); (2004).

7.5.4 Other Provenances

Northern Italy, Central Italy, and Gaul formed the three main provenances for fineware in the region during the first-second centuries AD but, in addition to these, finewares from North African and Asia Minor, in the form of ARS and ESB respectively, appeared in small quantities. These were predominantly found at the Adriatic ports during the first-second centuries AD. Given that CITS and NITS continued to be the dominant components of the Adriatic port assemblages, the finds of ARS and ESB seem more indicative of one-off purchases, the sale of surplus cargo, or relate to the movement of people instead of sustained trade. There was little penetration of ARS further inland during this period. It comprised 3% of the assemblage at Augusta Bagiennorum and 1% at Alba, appearing in marginal quantities of <1% at Milan and Turin. ESB appears in similarly low quantities inland, comprising 3% of the assemblage at Padua, 2% at Julia Concordia, and 1% at Brescia. It appeared in marginal quantities of <1% at Milan. If finewares generally did not travel by themselves but piggy-backed on other maritime cargoes, this may help explain some patterns of distribution.⁶¹ Most inland sites with ARS in their assemblages are located in the western valley. ARS likely entered the region via the Apennines from the Ligurian seaboard, perhaps travelling with the small quantities of African amphorae discovered in the south-west of the Po valley during the same period (see Section 6.3.2), or other perishable North African cargoes.⁶² A similar pattern is seen for imports of ESB. As most of the sites returning examples of ESB are located in the eastern valley, these finewares may have travelled with amphorae from the Eastern Mediterranean, which are numerous in the eastern valley.⁶³

7.6 Discussion: The Third-Fifth Centuries AD

While it is evident that the third-fifth centuries AD saw massive changes in the trade of finewares in Northern Italy, the unevenness of the published evidence makes it difficult to analyse these changes in detail. Echoing the amphora data, the diversity of fineware assemblages in Northern Italy remained high during the third-fifth centuries AD. Although the available provenances for finewares de-

⁶¹ See Fulford (1987), 59–62; Reynolds (1995), 128–29; and Tomber (1993) for discussion on how finewares travelled.

⁶² Bonifay and Tchernia ((2012), 322–24) highlight that it is rare to find cargoes of ARS travelling with North African amphorae. See also Bonifay (2018), 334–36.

⁶³ There is an interesting question of markets here. There was obviously a demand for the goods being carried in Eastern Mediterranean amphorae in the region, the second most common amphora provenance in the eastern valley during the first-second centuries AD. However, there seems to have been very little demand for Eastern Sigillata.

creased from the second to third century, the number of individual vessel types circulating remained high. This is supported by the greater dissimilarity between assemblages compared to earlier periods, with most sites at least 50% dissimilar in vessel composition in the third and fourth centuries AD. This had increased to over 75% dissimilarity in the fifth century AD, although could also reflect the lower quantity of finewares recovered datable to this period as opposed to a genuine increase in the variety of vessels present at each site.⁶⁴ While no single vessel type dominated the assemblages, many sites contained high levels of one or two fineware forms (see Appendix C).⁶⁵ The Adriatic ports often returned the highest Simpson's Index scores for diversity during the third-fifth centuries AD, reflecting their role as the primary entry point for finewares into the region during this later period. Their access to MATS which, as discussed above, did not widely circulate inland, also contributed to the high diversity of vessels present at Adriatic port sites. Aside from the Adriatic ports, Milan also consistently demonstrated greater diversity in its assemblage, perhaps reflective of its increasing importance during this later period as an imperial capital in the late AD 280s and the new demand and greater economic pull this afforded.

In contrast to the first-second centuries AD, the majority of finewares recovered from the region during the third-fifth centuries AD were maritime, rather than overland imports. CITS was entirely absent from assemblages in this period, with GTS only appearing in appreciable quantities at Cividate Camuno. Although NITS was recovered from four of the five inland sites: Alba, Brescia, Milan, and Verona, it was only present in significant quantities at Alba, Brescia, and Verona. The decline in CITS, NITS, and GTS production saw a major reorientation in the locations supplying fineware to Northern Italy in the third-fifth centuries AD. North Africa now formed the main provenance for fineware, representing a shift from predominantly short-distance trade to predominantly long-distance trade supplying the region. The dominance of ARS in third-fifth century fineware assemblages is a pattern repeated across the Mediterranean world.⁶⁶ Given their North African provenance (mainly Tunisian given the quantity of sherds belonging to fabric groups C and D recovered), ARS cargoes must have initially entered the region via its maritime ports. ARS would have

⁶⁴ The declining quantity of ARS present at sites in Northern Italy during the fifth century is, however, consistent with a more general decline in their export across the Mediterranean at this time (Bonifay (2018), 337; Fentress et al. (2004)).

⁶⁵ The reason behind this is uncertain. The dominant vessels varied from assemblage to assemblage and could perhaps be indicative of cargoes composed of single fineware forms at each site.

⁶⁶ Bonifay (2003); (2004); Bes (2015), 122-28. ARS has been found in significant quantities across sites in the upper Adriatic area but has yet to be studied at a regional level (Biondani (2014), 229).

needed to travel over the Apennines to reach the western valley if it originated from the Ligurian ports. If ARS arrived at the Adriatic ports, then either overland or fluvial transport was an option. Beyond this, the quantity and ubiquity of ARS in assemblages across the region makes it difficult to ascertain how it was distributed within Northern Italy.

Against the backdrop of ARS imports, some regional fineware production seems to have continued, as evidenced by the recovery of Late NITS from the sites of Alba, Brescia, Milan, and Verona. Alba returned the highest quantities of Late NITS in its assemblage (over 50%), resulting in placing independently of a cluster. Brescia and Verona also contained higher levels of Late NITS than the majority of sites in the region (23.4% and 20.7% respectively). The Late NITS found at these sites shared many characteristics: thin or opaque slip, variable colouring, imitation of Gallic and North African vessel forms, and friability (due to being fired at sub-optimal temperatures).⁶⁷ Late NITS was absent from all other sites apart from Milan, where it appeared in marginal quantities. A sudden cessation of sigillata production in Northern Italy, suggested by the absence of Late NITS in the most third-fifth centuries AD assemblages, seems unlikely. The absence of a typology, difficulty in its identification (especially regarding vessels that imitate ARS and GTS), and a lack of specialists, coupled with the relatively poor publication of later fineware assemblages that are not ARS, means that the scale of later NITS production is probably under-represented in the assemblages discussed here.⁶⁸ This makes it impossible to determine whether the high quantities of Late NITS found at Alba, Brescia, and Verona are an isolated phenomenon or are perhaps representative of wider Late NITS production obscured by the archaeological record and publication practices.

The final provenance for finewares in Northern Italy seen in the third-fifth centuries AD was the Middle Adriatic. MATS may have travelled either overland or by sea from production sites on the coast of Southern Emilia-Romagna and Central Marche.⁶⁹ The high quantity present at Ariminum and Forlì is likely reflective of their proximity to production sites in Emilia-Romagna. However, with the exception of these two sites, MATS remained a minor part of assemblages along the Adriatic coastal plain. Although it made up 24.7% of the third-fifth centuries AD assemblage at Aquileia, it only formed 8% of the one at Altinum. Furthermore, although it was found in low quantities at Brescia and Verona, MATS failed to penetrate further inland. In a similar matter to NITS produced during this later period, the difficulty of identifying MATS and a lack of specialists

⁶⁷ Jorio (1999), 83; Morandini (2008b), 332; Robino (2017), 71; Volonte (1997a), 443.

⁶⁸ Massa (1999); Morandini (2000), 165-66; Morandini (2008b), 332-33; Olcese (1998), 18-19.

⁶⁹ Biondani (2005d), 117-78; Tortorella (1996), 325.

may mean that this fineware is under-represented in assemblages in the eastern valley and Adriatic coastal regions. For both NITS and MATS, there are questions as to why these finewares, despite being produced within or adjacent to Northern Italy, were unable to compete with ARS. It is possible that NITS and MATS were not produced in quantities sufficient to meet the demand for sigillata within Northern Italy. They were also produced to a lower quality than ARS and may not have had the same desirability as North African finewares amongst consumers. If ARS was travelling alongside other North African goods being imported into the region, it would have had a further advantage, although, in the case of Alba, the cost of transporting ARS to the western valley may have allowed late NITS to be more competitive than elsewhere in the region.

7.7 Conclusions

Finewares within Northern Italy were traded in a markedly different way to the amphorae discussed in the previous chapter. The finewares trade in Northern Italy during the first-second centuries AD was dominated by short-distance, rather than long-distance trade, with demand for red-slipped tablewares predominantly met by regional production. This was particularly true for the central and eastern valley, where site assemblages were mainly composed of NITS. The majority of finewares recovered from assemblages had a Northern Italic provenance, which, on the basis of their associated stamps, were mainly traded over short distances. However, the western valley shows increased integration with extra-regional economies, particularly those in Southern Gaul and Central Italy, with its assemblages having the greatest composition of non-NITS finewares. In addition, the main method of entry into the region for finewares and their subsequent distribution seems to have been overland, rather than fluvial or maritime. This formed a stark contrast to amphora-borne goods, most of which had travelled over long distances to reach Northern Italy and were likely redistributed via the water network. Trans-Alpine and trans-Appennine trade made a key contribution, with finewares crossing the mountains via pack animals to reach markets in Northern Italy.

The limited publication of data from the third-fifth centuries AD obscures the true picture of how finewares circulated during this period, although several clear patterns were visible. Mirroring the third-fifth centuries AD amphora data, the decline of production areas that had previously supplied Northern Italy led to the creation of new trade networks, with most finewares now originating from regions that had previously played a marginal role in supplying Northern Italy. In

addition, new areas of production, such as the Middle Adriatic, also contributed to supply. The dominance of ARS during this later period reflects a shift from short-distance to long-distance trade and a greater reliance on extra-provincial economies to meet the demand for finewares within the region.

The fineware dataset for Northern Italy highlights the different levels and mechanisms of trade present in the region during the Roman period. There were many similarities and differences between the fineware and amphora datasets, although both reflected the compromises buyers made between practicality and choice in the wares they consumed. The final chapter of this part of the thesis analyses a dataset of decorative stone and marble from Northern Italy, a material that was consumed and travelled in a vastly different way from the ceramics studied so far.

Chapter 8

Decorative Stone

One of the greatest logistical and commercial feats of the Roman era was the extraction and export of vast quantities of decorative stone across the Mediterranean.¹ As Rome's expansion brought new sources of material under its control, a flourishing trade in high quality stone, principally marble, was established across the Mediterranean world, reflected in the construction and decoration of buildings, statuary, and funeral monuments.² In Northern Italy, worked marble objects are ubiquitous finds and are seen in both public and private contexts. They include the monolithic marble columns seen in the *capitolia* of Brescia and Verona, marble and granite sarcophagi in the necropoleis of Aquileia, Modena, and Pavia, and polychrome marble wall revetment and paving present in private homes and public buildings from Ravenna to Aosta.³ The widespread inland circulation of decorative stone is not a situation unique to Northern Italy, yet its distribution represents an oft-overlooked aspect of the Roman economy.⁴ Many studies are content to limit their analysis to the more numerous (and often better published) ceramic assemblages, and while these are undeniably important commodities, they represent only part of the picture.

The inclusion of decorative stone in an analysis of regional trade is important for a number of reasons. First, stone is a heavy material. Cargoes of stone, especially blocks or columns, were more difficult and costly to move than amphorae and finewares, which put limitations on their circulation. Consequently, they represent communal or elite investment, as opposed to widely consumed essentials and commodities. Second, shipments of stone were also specialist cargoes.

¹ Russell's (2013) book *The Economics of the Roman Stone Trade* forms the definitive volume on this topic.

² Lazzarini (2019), 367-69; Pensabene (2002). While imported decorative stone had been used in Rome for several centuries previously, Augustus' reign saw a significant increase in the scale of extraction and transport of stone.

³ Cavalieri Manasse (2008b); Framarin and Castoldi (2013); Gabelmann (1973); Guarnieri et al. (2018); Kleineberg (2021).

⁴ Russell (2018b), 237.

Consignments of stone, whether for building, decoration, or sculpture, were normally commissioned for a specific project or purpose. As a result, they primarily represent one-off purchases, rather than intensive and sustained trade between areas. Furthermore, the varying forms stone took presented different challenges for transport. A monolithic column was far more difficult and dangerous to move than blocks destined to be used as paving or revetment.⁵ They were commissioned via separate methods, utilised different supply mechanisms, and do not represent like-for-like investment. Of all the material finds discussed so far, stone is the most indicative of the power of the consumer, principally in public construction but also private projects, in dictating supply and overcoming obstacles in the movement of goods. For these reasons, it forms a necessary comparison to the material discussed in the previous sections.

This chapter uses the assembled decorative stone data from Northern Italy to analyse patterns in the trade of heavy cargoes in the region between the late-first century BC and the fifth century AD. It primarily focuses on high-end stones used for decoration, carving, and architectural elements, as opposed to the more common stone used in regular construction (although the importance of such stone is acknowledged – and indeed certain stones were moved significant distances even for such construction). The results from the analysis are presented, outlining where the majority of stone imports originated, and how this changed across the region. In addition, the importance of regionally sourced stone and marble in construction and decoration, alongside the creation of burial monuments such as sarcophagi, is commented on. Indeed, in several parts of the region, imported stone complemented, rather than replaced, locally extracted materials. Areas of Northern Italy that exhibited high or low diversity in their decorative stone assemblages are highlighted, and reasons offered as to why this might have been the case. These patterns are then situated within a geographical framework, allowing their evolution to be examined. Finally, the significance of the results are situated within wider discussions on inland economies and the Roman stone trade. The locations of sites mentioned within this chapter can be viewed in Figure 8.1.

8.1 The Roman Stone Trade

Imported decorative stones, especially white, grey, and polychrome marbles and granites, were widely consumed across the Roman world. Polychrome stone could only be acquired from a select number of quarries. For example, green stone and marble such *cipollino verde*, *serpentino*, *verde antico*, or *porfido verde Egiziano*,

⁵ Russell (2013), 144.

could only be extracted from Greece or Egypt.⁶ There was more scope for choice when it came to selecting a supply of white or grey marble, although the majority of extraction sites were still located in the Eastern Mediterranean.⁷ As highlighted above, the stone trade presented numerous economic and practical limitations not shared by ceramic materials. Many of the challenges linked to the transportation of heavy cargoes have already been discussed in detail in previous chapters (see Section 4.2), but the unique mechanisms behind the supply and consumption of decorative stone warrant further exploration.

In the past, the ubiquity of imported decorative stone across the Roman world led to the suggestion that they were transported *en masse* and stockpiled for use in local construction projects.⁸ However, on close examination, the evidence for stockpiling has proven unconvincing and patchy, with the exception of a few unique sites such as Portus and the *Emporium* district in Rome.⁹ It is more likely that architectural elements, such as columns and capitals, would have needed to have been commissioned from the quarries directly by contractors such as *marmorarii* and *lapidarii*.¹⁰ The same may also have been true for sarcophagi, although the situation is more complex.¹¹ In most cases, the blank chests that would become sarcophagi were roughed out at the point of extraction, before being shipped to local independent workshops (often located near urban centres), where they would be completed according to regional tastes and the desires of the commissioner.¹² Large workshops, with sufficient capital to absorb the risks involved and a stable market, may have been able to stock limited quantities of blank chests.¹³ However, it is probable that most sarcophagi would have been

⁶ See Lazzarini (2019), for a catalogue of polychrome stone and marble used in the ancient world.

⁷ Antonelli and Lazzarini (2016).

⁸ This is the production-to-stock model proposed by Ward-Perkins, where he envisioned that increasing demand for stone in the Early Imperial period saw the production of stone take place along ‘quasi-industrial’ lines. This allowed quarries to generate quantities of standardised material for export to stockpiles across the Roman world. See Ward-Perkins (1980); (1992). For a critique of the production-to-stock model, see Russell (2013), 232-39, alongside Chapter 6 more widely.

⁹ Russell (2013), 235-36.

¹⁰ See Russell (2013) Chapter 6, particularly pp. 207-28, for an exploration of the relationship between building projects and stone supply.

¹¹ For a thorough analysis of the mechanics behind the Roman sarcophagus industry, see Russell (2011).

¹² Russell (2013), 257. Over half of all known sarcophagi are thought to have been produced by such workshops, although the Attic and Dokimeian workshops may have operated in a different way (Russell (2013), 124-27). In the past, it has been argued that some quarries maintained branch workshops, which were responsible for completing, and selling the finished sarcophagus to local communities, however this has been convincingly challenged by Russell ((2011); (2013), Chapters 6 and 7).

¹³ Russell (2011), 138.

produced and shipped in response to a specific commission by a workshop.¹⁴ Wall revetment and floor panelling also represent something of a grey area. Floor panels and revetment, alongside some minor architectural elements, may have been stockpiled by local workshops or craftsmen. The demand for veneer and paving in both public and private contexts, coupled with the high surface area of material that could be extracted from a single block, made them a less risky investment.¹⁵ Indeed, it seems unlikely that contractors for private construction would have ordered blocks of marble for veneer production from quarries to fulfil individual project requirements. Such an endeavour may have been prohibitively expensive, given the variety of colours often used and cost of transport.¹⁶ Instead, the veneer used in private projects is likely a reflection of the stock contractors had on hand, rather than a bespoke order. Furthermore, it is unlikely that every city was equipped with the necessary tools and expertise to cut marble blocks into veneer panels; at more minor centres, floor and revetment tiles arrived pre-made.¹⁷

While finds of imported lithotypes are numerous across Northern Italy, it is worth highlighting the fact that the region itself was not lacking in sources of decorative stone, including marble. These resources could, and did, provide an alternative to imported stones, with Figure 8.2 displaying the location of stone deposits known to have been quarried in Northern Italy during the Roman period.¹⁸ Indeed, the majority of stone used by construction projects would have been locally extracted and transported a minimal distance; imported materials complimented supplies sourced within the region.¹⁹ Although no stone extracted from the Po-Veneto region saw widespread diffusion across the Mediterranean world, several types seem to have been of sufficient quality (and/or the quarries sufficiently accessible) to enable regional circulation. Studies on the extraction and distribution of decorative stone from Northern Italy are still quite limited, but substantial progress has been made on tracing the uses and distribution

¹⁴ Russell (2013), 271-72.

¹⁵ Stepped blocks that could be cut into veneer panels may also have been kept in stock (whether intentionally or unintentionally assembled) at the quarries themselves (Peacock and Maxfield (1997), 213–14; Russell (2013), 234-36).

¹⁶ It is worth noting that there is some evidence for the trade of pre-cut veneer panels from the Chrétienne (Joncheray and Joncheray (2007)), La Mirande (Descamps (1992)), Porto Nuovo (Bernard et al. (1998)) and Torre Sgarrata (Throckmorton (1989)) shipwrecks. See also Russell (2008). There is also the possibility that some veneer panels may have been bought second-hand after being salvaged from previous projects. On this point, see Fant et al. (2013).

¹⁷ Russell (2013), 253. This would also have made stone and marble easier to transport and handle.

¹⁸ The quarries presented here are by no means a complete list of all quarries operating in Northern Italy during the Roman period.

¹⁹ Russell (2018b), 242-43. See Mosca (2015) for distribution related to stone quarried in the eastern Alpine area.

Site	N. Fragments	Context	Publication
Alessandria	54	Misc. Urban Excavations	Gomez Serito (2007)
Altinum	365	Field Survey	Minato (2018)
Aosta	141	Forum	Framarin and Castoldi (2013)
Aquileia	1567	<i>Domus</i> of ‘Bestie Ferite’ and ‘Titus Macro’	Previato and Mareso (2015)
Augusta Bagiennorum	300	Theatre	Gomez Serito and Rulli (2014) Rulli (2008)
Brescia	821	<i>Capitolium</i>	Angelelli (2014)
Como	42	The via Parini	Bugini and Folli (2016)
Forlì	102	<i>Domus</i> dell’ex Vescovado	Guarnieri (2013a)
Milan	250	Misc. Urban Excavations	Terracina (1991)
Ravenna	45	<i>Domus</i> del Genio delle Acque	Guarnieri, Montevecchi, and Pagani (2018)
Tortona	77	Misc. Urban Excavations	Gomez Serito (2007)
Vercelli	148	<i>Domus</i> di Monastero della Visitazione	Cardosa (1996)
Verona	14,712	Forum	Bocconcello (2008)

Table 8.1: Decorative stone assemblages analysed in Chapter 8.

of several prominent lithotypes, such as Aurisina limestone, Candoglia marble, Euganean trachyte, and *Verona rosso*.²⁰ The cargoes of several inland shipwrecks also attest to the movement of stone via water within the region (see Section 3.1.4). The best documented of these is the Bacchiglione wreck, with its cargo of architectural elements in Euganean Trachyte, but the San Basilio di Ariano Polesine wreck with its cargo of Domegliara limestone and the Como wreck with its cargo of Musso marble are also valuable examples.²¹

8.2 Analysis

Using the parameters outlined in Chapter 5, a total of ten assemblages of veneer and floor panels from inland urban centres across Northern Italy were compiled for analysis. Three port assemblages from the Adriatic coast were also examined to provide points of contrast: Altinum, Aquileia, and Ravenna. Due to the low number of sites in the stone dataset and the absence of a quantified dataset

²⁰ Euganean Trachyte was a durable stone quarried in the Colle Euganea near Padua during the Roman period. The lithotype played an important role in construction projects across the east of Northern Italy, with its distribution suggesting it was primarily transported by water (Germinario et al. (2018); Previato and Zara (2018); Zara (2018), Part 3). Candoglia marble is still extracted in the present day at the mouth of the Ossola valley, adjacent to Lago Maggiore (Poletti Ecclesia (2019), 41-43). Aurisina limestone is quarried close to Trieste in the Karst region. Examples of structures and artefacts comprised of Aurisina limestone have been found as far west as Pavia and Milan (Previato (2018), 937-38). *Verona rosso* was quarried close to Domegliara, north of Verona, and saw wide diffusion across Northern Italy (Calzolari (2003), 169-70).

²¹ Dallemulle (1977), 123-24; Montalcini De Angelis D’Ossat (1993), 56; Previato and Zara (2014), 61-63.

for the Ligurian coast, the Adriatic port sites were not initially separated from inland sites in the analysis, as had been the case for the amphora and fineware datasets. All sites selected for analysis can be seen in Table 8.1 and are mapped geographically in Figure 8.3. The number of fragments within the dataset totalled 18,624. The total number of fragments of each lithotype present at individual sites can be found in Appendix C.

8.3 Results

Despite the reduced number of assemblages present in the decorative stone dataset, interesting trends were revealed in its analysis. Although the stone data lacked a chronological aspect, several geographic patterns in both the provenance and diversity of the assemblages were observable.

Fifty-six lithotypes were present within the marble dataset (see Figures 8.4 to 8.10). Of these, Proconnesian marble was the most commonly attested lithotype, forming 19.2% of the total stone assemblage and accounting for the majority of provenanced white marble within the dataset (see Figure 8.11).²² *Africano* and *pavonazzetto*, both from Asia Minor, were also well attested (see Figure 8.12 and 8.13).²³ From Greece and the Aegean, green *cipollino* formed the second most common lithotype across the entirety of the stone assemblage (see Figure 8.14).²⁴ *Cipollino* was also the most commonly attested polychrome marble within the dataset. *Breccia di Settebasi* from Skyros and *marmo Lesbio* from Lesbos formed other dominant lithotypes from Greece and the Aegean (see Figures 8.15 and 8.16).²⁵ A diverse range of decorative stone was recovered from Egypt and North Africa. *Giallo antico* formed the dominant lithotype, with other decorative stone from Egypt and North Africa appearing in quantities of <1% of the total assemblage (see Figure 8.17).²⁶ From quarries in the Italian peninsula, grey *bardiglio* formed the most common lithotype (see Figure 8.18).²⁷ White Luna marble formed the second most common Italian lithotype within the dataset, although

²² For information of Proconnesian marble, see: <http://www.oum.ox.ac.uk/corsi/stones/view/4> (Accessed 11/01/2022).

²³ For information on *africano*, see: <http://www.oum.ox.ac.uk/corsi/stones/view/108> (Accessed 11/01/2022). For information on *pavonazzetto*, see: <http://www.oum.ox.ac.uk/corsi/stones/view/123> (Accessed 11/01/2022).

²⁴ For information on *cipollino*, see: <http://www.oum.ox.ac.uk/corsi/stones/view/90> (Accessed 11/01/2022).

²⁵ For information on *breccia di Settebasi*, see: <http://www.oum.ox.ac.uk/corsi/stones/view/405> (Accessed 11/01/2022). For information on *marmo Lesbio*, see: <http://www.oum.ox.ac.uk/corsi/stones/view/6> (Accessed 11/01/2022).

²⁶ For information on *giallo antico*, see: <http://www.oum.ox.ac.uk/corsi/stones/view/22> (Accessed 11/01/2022).

²⁷ For information on *bardiglio*, see: <http://www.oum.ox.ac.uk/corsi/stones/view/153> (Accessed 11/01/2022).

appeared in much lower quantities than *bardiglio*, which came from the same quarrying district (see Figure 8.19).²⁸ A wide variety of Alpine lithotypes were present in the region, but of these, only *Verona Rosso* was recovered in significant quantities (see Figure 8.20).²⁹ Only two lithotypes from Gaul were recovered, *bianco e nero antico* and *cipollino mandolato* (see Figures 8.21 and 8.22).³⁰

In comparison to the amphora and fineware assemblages, a large portion of the stone and marble assemblage (27.59%) had an unknown provenance (see Figure 8.23). Unprovenanced lithotypes consist almost solely of white marble, the type and origin of which is difficult to securely identify without petrographic and mineralogical analysis. As the Po-Veneto region does not possess any known deposits of pure white marble its provenance is likely extra-regional, however, beyond that, there is little else that can be gleaned from the data.³¹ The marble revetment that could be provenanced originated from six different zones of extraction: the Alps, Asia Minor, Egypt and North Africa, Gaul, Greece and the Aegean, and the Italian peninsula (see Figures 8.24 and 8.25). Of these, Asia Minor formed the most common provenance, accounting for 43.2% of revetment fragments recovered. Mainland Greece and the Aegean formed the second most common provenance (33.3%), followed by the Italian peninsula (10.1%), Egypt and North Africa (8.6%), and the Alps (4.1%). Lithotypes from Gaul accounted for < 1% of the total assemblage.

When the marble assemblage was separated by colour, the dominant provenances changed (see Figures 8.26 and 8.27). Grey marble was predominantly sourced from the Italian peninsula, with Greece and the Aegean forming the second most common provenance. Polychrome stone and marble mostly originated from Greece and the Aegean, with Asia Minor and North Africa forming the second and third most common provenances. White marble was mainly sourced from Asia Minor, with the Italian peninsula forming the second most common provenance. However, as most of the white marble recovered from the region is unprovenanced, this pattern could easily change.

When the sites were hierarchically clustered using the UPGMA algorithm based on the provenance of their stone and marble assemblages, three clear groups emerged (see Figures 8.28 and 8.29).³² The first cluster was comprised of five sites,

²⁸ For information on white Luna marble, see: <http://www.oum.ox.ac.uk/corsi/stones/view/9> (Accessed 11/01/2022).

²⁹ For information on *Verona Rosso* see <http://www.oum.ox.ac.uk/corsi/stones/view/70> (Accessed 11/01/2022).

³⁰ For information on *bianco e nero antico*, see: <http://www.oum.ox.ac.uk/corsi/stones/view/125> (Accessed 11/01/2022). For information on *cipollino mandolato*, see: <http://www.oum.ox.ac.uk/corsi/stones/view/86> (Accessed 11/01/2022).

³¹ Although some sources of white marble exist in the Po-Veneto region, such as Foresto or Tre Piloni, these are not pure white marbles (Betori et al. (2009); Gomez Serito (2019)).

³² As quantified data for the weight and volume of the stone assemblages was present for

Altinum, Aquileia, Brescia, Ravenna, and Verona. These were all sites east of the region's centre and contained high quantities of imported stone and marble in their assemblages. Asia Minor and Greece and the Aegean formed the main provenance of lithotypes within this cluster. Quantities of decorative stone from Asia Minor ranged from 40.3% at Aquileia to 47.3% at Altinum, while quantities of decorative stone from Greece and the Aegean ranged from 33.8% at Verona to 50% at Ravenna. The second cluster contained three sites in the north-west of the region, Como, Milan, and Vercelli, which possessed the highest quantities of Alpine stone in their assemblages. This ranged from 15.8% of the assemblage at Milan to 41.4% of the assemblage at Vercelli. The final cluster was comprised of five sites: Alessandria, Augusta Bagiennorum, Aosta, Forlì, and Tortona. This cluster contained the sites with the highest quantities of Italian stone in their assemblages, ranging from 36.1% at Tortona to 68% at Alessandria. These sites were mainly located in the west of the valley, with the exception of Forlì.

When the diversity of the lithotypes present at each site were measured using Simpson's Index, scores ranged from 0.92 at Ravenna to 0.57 at Alessandria (see Figure 8.30). All sites scored over 0.5 on the Index, suggesting greater diversity than homogeneity in their assemblages. Sites that returned high quantities of Italian lithotypes in their assemblages, principally located in the south and west of the region, returned the lowest diversity scores. When the contents of each assemblage were compared using the Morisita-Horn Overlap Coefficient, three clusters formed (see Figure 8.31). The first cluster contained sites that did not have a single dominant lithotype, while sites in the second cluster had high quantities of Proconnesian marble present in these assemblages. The third cluster of western sites contained high quantities of white Luna marble in their assemblages. Of the three clusters, only the third grouped geographically. Most assemblages returned a distance of under 0.5, suggesting a high level of overlap both within the clusters and across the dataset more generally.

In summary, the trade in marble revetment within Northern Italy saw a wide variety of lithotypes from across the Mediterranean distributed across the region. Within the eastern Po-Veneto plain, stone and marble from Asia Minor, Greece and the Aegean, and Egypt and North Africa comprised the majority of assemblages. Sites in the east of the region also showed greater diversity and less overlap in the lithotypes present in their assemblages. At sites in the western valley, Alpine and Central Italic lithotypes comprised a much greater part of the assemblages, although white, grey, and polychrome stone from the Eastern

Aquileia and Milan respectively, these values were substituted into the hierarchical clustering to observe if they changed the pattern. Although the percentages of some provenances changed significantly, the distribution of the clusters was unaffected.

Mediterranean and Egypt and North Africa was still present. The assemblages of these sites exhibited less diversity and greater overlap, particularly sites in the west and south-west of the valley.

8.4 Discussion

As with the amphora and fineware data examined in the previous chapters, there was a clear distinction between the contents of decorative stone assemblages present at sites in the east and west of Northern Italy. Out of all the datasets examined in the thesis, the role of geography and its impact on transport was most apparent in the stone assemblages, with topography having a clear effect on the lithotypes present in different areas of the region.

8.4.1 The Eastern Valley and the Dominance of Imports from Asia Minor

The assemblages of most sites in the central and eastern Po-Veneto plain were defined by high quantities of stone imported from the Eastern Mediterranean and Egypt and North Africa, in particular, marble from Asia Minor. The majority of sites in this part of the region (with the exception of Brescia), had lower levels of overlap and higher levels of diversity within their assemblages. Furthermore, these sites also contained the greatest quantities of polychrome marble in their assemblages, compared to sites further inland that returned greater quantities of grey and white marble.³³ Proximity to the coast gave these sites access to a greater range of material and reduced the cost of its distribution to sites in the coastal hinterland and middle valley. Arriving at the Adriatic ports would also have allowed imported stone to be redistributed via the river network, reducing its transport costs as it moved further inland.³⁴ Furthermore, the relatively flat topography of the valley floor would have served to limit the impact of gradient on overland transport, resulting in lower costs. For comparison, the unforgiving terrain of the Anatolian coastal hinterland and the absence of navigable rivers served to limit the quantity of imported stone that reached inland sites in Asia Minor.³⁵

³³ Ravenna formed an exception to this rule, but this is likely due to the small size of its assemblage.

³⁴ A similar situation is seen in the distribution of marble in the Ebro valley (Cisneros (2018)). Although as mentioned above, for items that were not revetment or floor tiles, it may have been easier and safer to travel solely overland rather than risk losing the cargo via fluvial transport or transshipment.

³⁵ Corremans et al. (2012); Lazzarini (2004), 107-8.

Of the Eastern marbles attested in Northern Italy, Proconnesian was imported in the greatest quantities, making up the majority of white marble identified within the region. Pentelic and Thasian marble were barely attested in the stone dataset and Parian, the other Eastern white marble that saw widespread distribution during the Roman period, was absent entirely. The dominance of Proconnesian marble is at first somewhat surprising, given that the closest source of white marble to Northern Italy were the quarries at Luna. However, Luna marble was only present in significant quantities in the south-west and west of the Po valley (see below). As hypothesised by Russell, the archaeological evidence suggests that, in large parts of the region, it was cheaper to import marble from Proconnesus, rather than geographically closer quarries at Luna.³⁶ The quarries at Luna, despite their proximity to Northern Italy, were located on the other side of the Apennines, an expensive and arduous journey away. Later sources indicate that the 10 km overland journey from the quarry to the port of Luna alone nearly doubled the cost of a block of marble.³⁷ If a maritime, rather than overland, route was selected to enter Northern Italy, then the marble would have needed to be transhipped from wagon or sledge to ship, before making its way around Italy to the Adriatic ports, adding further costs. In contrast to Luna marble, Proconnesian marble travelled a minimal overland distance from its point of extraction to waiting maritime transport, giving it an edge on cost before it had even arrived within the region.³⁸

The distribution of Proconnesian marble, alongside the dominance of Eastern Mediterranean and Egyptian and North African lithotypes in the east and central Po-Veneto plain, demonstrates the importance of the Adriatic coast and its ports in the region's stone trade. Facing the Eastern Mediterranean, the Adriatic coast offered access into the valley without having to cross the major barrier of the Apennines. The plain's relatively flat topography and the presence of the river network helped imported stone and marble penetrate far inland. However, in a similar manner to the amphora data, assemblages in the far west of the region exhibited very different compositions to their eastern counterparts, as distance and cost began to impact on distribution.

³⁶ Russell (2018a), 139-40.

³⁷ Russell (2018a), 140.

³⁸ Russell (2013), 262; Ward-Perkins (1980), 329-34. This is in comparison to other marbles from Asia Minor, such as *pavonazzetto*, which had a lengthy overland journey to reach ports on the coast (Corremans et al. (2012), 45-46). Proconnesus' position would also have afforded it an advantage against Pentelic marble, although not Thasian, the quarries for which were also located on the coast.

8.4.2 Alpine Stones in the North-West

Moving further inland, sites in the north-west of the region saw decreasing quantities of imported marble in their assemblages and greater reliance on locally quarried lithotypes. This is seen most clearly in the cluster formed by Como, Milan, and Vercelli. The assemblages from these sites contained high quantities of Alpine stone and marble, the exact lithotypes of which were often uncertain. Several good sources of Alpine marble were close to Como, Milan, and Vercelli, most notably the quarries at Musso on the cliffs above Lake Como and those along the Val d'Ossala close to Lago Maggiore. From quarries such as those at Musso and Candoglia, it would have been impractical, if not outright impossible, to transport large quantities of stone overland.³⁹ The narrow, undulating roads that hugged the hills surrounding the great glacial lakes of Como and Maggiore would have been unsuitable for the transport of heavy loads such as the monolithic columns in Musso marble preserved by the Colonne di San Lorenzo in Milan.⁴⁰ The lakes themselves, and the connecting river network, provided a more practical alternative transport route.

Como and Vercelli, located in the north-west of the region, lay at the furthest point from both the Adriatic and the Ligurian Apennines, the two entry points for imported lithotypes in Northern Italy. The distance of these sites from the coast, and the associated transport costs of transporting heavy loads of stone and marble inland, may have served to limit the quantity of imported lithotypes available, forcing a greater reliance on local sources of material.⁴¹ It is, however, important to emphasise that despite the higher quantities of Alpine materials present at these sites, imported lithotypes still make up over 50% of each assemblage. Very few Central Italian lithotypes were attested at these sites (4.1% of the assemblage at Milan, 2.8% of the assemblage at Como and absent from Vercelli's assemblage), suggesting a greater reliance on stone traders in the eastern valley than those dealing in cross-Apennine trade. The overland route from quarries on the Ligurian coast, followed by either transshipment to river transport or a continuing overland journey to reach sites in the north, seems to have made Central Italic lithotypes prohibitively expensive compared to their Mediterranean counterparts.

³⁹ Although Candoglia marble is not attested in any of the assemblages discussed above, it is present in many rural assemblages in Northern Piedmont and Western Lombardy (Poletti Ecclesia (2019), 43-44).

⁴⁰ Fiorio and Bandera Bistoletti (1985), 409. The columns, originally from a second or third century AD temple and/or bathhouse, were reused in the construction of the Basilica di San Lorenzo during the fourth-fifth centuries AD.

⁴¹ A similar situation is seen in the Ebro valley, with sites in the middle and upper river containing greater quantities of Pyrenean stone than coastal sites (Andreu Pintado et al. (2015)).

8.4.3 Central Italian Lithotypes: A Limited Distribution

The final group of sites from the hierarchical clustering consisted mainly of sites in the west and south-west of the region, alongside Forlì in the south-east. The sites in this cluster contained the lowest levels of stone and marble from the Eastern Mediterranean and Egypt and North Africa, with the exception of Tortona that retained high quantities of stone from Asia Minor. It is possible that the transport costs associated with heavy cargoes of marble revetment from the Adriatic coast began to limit the quantities and selection of Egyptian and North African and Eastern Mediterranean stone entering this part of the region, as suggested by the network model in Chapter 4 (see Section 4.5.4). Equally, transporting Egyptian and North African and Eastern Mediterranean stone and marble across the Apennines may have been prohibitively expensive once prior transport and transshipment costs had been factored in. Aside from low quantities of Egyptian and North African and Eastern Mediterranean lithotypes, sites in this cluster shared high levels of Central Italian stone and marble within their assemblages. This mainly took the form of white Luna alongside grey *bardiglio* marble.⁴² The quarries, located near Luna, were approximately equidistant from sites in the eastern and western valley in terms of Euclidean distance, yet Central Italian lithotypes comprised less than 9% of assemblages outside of this cluster.

White Luna marble formed the main Central Italic lithotype present at Alessandria, Augusta Bagiennorum, Aosta, and Tortona. The other white marble appearing in large quantities within the region, Proconnesian, appears in much lower quantities in the west of the Po valley and was absent from the assemblages of Aosta, Augusta Bagiennorum, and Como. White marble from Luna seems to have been less expensive to transport to sites in the western valley, even after travelling over the Ligurian Apennines, than Proconnesian marble arriving at the Adriatic ports. However, as discussed above, these circumstances did not extend far beyond the west and south-western valley. Alessandria and Augusta Bagiennorum were close to passes to the Ligurian coast, as was Tortona. However, despite the high quantity of Central Italic lithotypes present at Tortona, its assemblage contained more Proconnesian than Luna marble, alongside other stone from Asia Minor. Further north, Central Italic lithotypes were also absent from Vercelli and comprised less than 3% of the assemblage at Como. As such, the area around Tortona may represent a transitional zone, marking an area where Luna and Proconnesian marble began to even out in price, with Luna gaining an edge in areas to the south and the west.

⁴² The true extent of the trade in Luna marble across the region will likely never be known given the amount of unprovenanced white marble contained in the assemblages.

While the high quantities of Central Italian lithotypes in Alessandria and Augusta Bagiennorum's assemblages can be explained by their proximity to the Ligurian coast, Aosta's placement in this cluster forms an interesting pattern. Aosta is located further away from supplies of Italian stone than Como, Milan, and Vercelli, three sites that contained high quantities by Alpine lithotypes.⁴³ The assemblage at Aosta also contained a high percentage of Alpine stone (25% of the lithotypes attested); however, the majority of its assemblage was comprised of Luna marble. The context of Aosta's assemblage, two temples from the forum area, as opposed to a road in Como and a townhouse in Vercelli, may have played a role in the quantity of Italian stone present at the site.⁴⁴ A project such as a temple, a prestigious architectural undertaking, would likely have been better funded than a domestic property. Given the temple's contemporary date to other Aostan monuments that use imported marble, such as the Porta Praetoria and the theatre, its use on the building may represent an attempt on the part of the city's inhabitants to increase its prestige in the context of a wider architectural program.⁴⁵ White marble from local quarries, such as those at Chianocco, Crotte, Foresto, and Tre Piloni, was available during this period (see below), and the decision to instead use the more prestigious (and expensive) marble from Luna represents a deliberate choice.

The fact that the white marble from Aosta is uniformly Luna, rather than Proconnesian, reinforces the theory that the cost of transporting imported Eastern and Egyptian and North African marbles from the Adriatic coast had become either too expensive, or comparable in cost to Central Italic imports, this far inland.⁴⁶ However, the decision to use Luna over Proconnesian marble may also be a reflection of availability. Luna was widely used in the Augustan period, before many other sources of marble were found or systematically exploited.⁴⁷ In contrast, the marble at Proconnesus would not see intensive extraction and distribution until the latter half of the first century AD, rising to prominence in the Adriatic and Eastern Mediterranean during the second and third centuries.⁴⁸ Consequently, Aosta's assemblage of decorative stone probably predates the wider availability of Proconnesian marble in Northern Italy. Regardless, in a hypothetical scenario where Luna marble was replaced by Proconnesian marble in Aosta's assemblage, the high quantity of Alpine lithotypes it contained would have seen it

⁴³ Aosta also had the lowest level of imported Eastern and Egyptian and North African marble of any site within the stone dataset, those provenances forming less than 20% of its assemblage.

⁴⁴ The residual context of the majority of Milan's decorative stone fragments makes it hard to identify their original setting.

⁴⁵ Betori et al. (2009); Vanni Desideri (2001).

⁴⁶ See Section 4.5.4.

⁴⁷ Bradley (2013), 2-11; Fant (1999).

⁴⁸ Attanasio et al. (2008), 747-48; Ward-Perkins (1980).

cluster with other sites in the north-west, rather than those in the eastern valley.

The contrast between sites in the east and west of the region, in particular the limitations on variety faced by inland sites, is further reinforced when the contents of assemblages in the west and south-west of the valley are analysed. The sites of Alessandria, Aosta, and Augusta Bagiennorum had the highest levels of overlap in their assemblages and were amongst the lowest-ranked on Simpson's Diversity Index, suggesting lower diversity in the types of stone and marble in their assemblages and greater overlap in the lithotypes present. Sites within this cluster were dominated by large quantities of Luna marble (accounting for the high overlap), with low numbers of other lithotypes appearing. This was especially true for material originating outside of the Alps and Central Italy. For example, at Augusta Bagiennorum, although almost 50% of the stone and marble assemblage was comprised of material quarried outside of Italy, only six lithotypes made up this total. This compares to a coastal site such as Aquileia, where over 90% of the assemblage was comprised of material quarried outside of Italy, with twenty-three lithotypes contributing to the total. Although their inland location did not prevent these sites from accessing imported Eastern and Egyptian and North African marbles, it does seem to have limited the choice of material on offer.

The inclusion of Forlì within a cluster dominated by Central Italic decorative stone was surprising given its proximity to the Adriatic ports of Ariminum and Ravenna, and the dominance of imported marbles in other sites in the east of the region. Unfortunately, without the publication and quantification of datasets from other sites in the south of the region, it is impossible to know if the high quantity of Italian lithotypes attested in Forlì is reflective of a wider trend in sites along the Apennines or a unique occurrence. As Forlì was well placed to take advantage of the coastal ports for imported marble, as shown by the high quantity of lithotypes from Greece in its assemblage, consumer choice may have played a role in the high quantity of Italian lithotypes recovered from the city.⁴⁹ *Bardiglio* was one of the few grey marbles extracted in significant quantities, the others being *greco scritto* and *marmo Lesbio*, and would have been an understandable choice if grey revetment was key to the building's decoration.⁵⁰

⁴⁹ Sites further inland, such as Brescia and Verona, also contained higher quantities of Eastern Mediterranean and North African lithotypes than Forlì.

⁵⁰ Leka and Zachos (2015). The high cost of overland transport for heavy loads of revetment, alongside the proximity of both the quarries and Forlì itself to ports, makes it probable that *bardiglio* was transported via maritime routes. Using the figures from the network model outlined in Chapter 4, the approximately 2000 km maritime journey from Luna to Forlì, including transshipment costs, came to 396 kg wheat per tonne of cargo. The equivalent overland route of approximately 350 km, came to between 1100 and 1200 kg wheat. See also Russell (2008), 114. *Greco scritto* and *marmo Lesbio* would have travelled a similar distance from quarries in the

8.4.4 Beyond Veneer: Comparative Data from Other Stone and Marble Datasets.

While the assemblage of revetment discussed above presents a picture of how decorative stone circulated within Northern Italy, it represents only part of the region's stone trade. Although unquantified, examples of carved stone in the form of architectural elements, building materials, and sarcophagi, form important comparisons.

The fact that most coloured stone recovered from sites in Northern Italy is in the form of veneer is a pattern reflected in other studies on the inland distribution of coloured stone.⁵¹ The cost of transporting material served to limit its applications to flooring and revetment, and slicing a block into slabs of panelling maximised its surface area and visibility of the stone, allowing more to be achieved for less.⁵² Large-scale architectural elements in imported stone and marble are almost entirely absent in the most westerly areas of the region. The Arch of Augustus at Susa, constructed between 9 and 8 BC, was built using mainly local white marble (Crotte, Foresto, and Tre Piloni) from the quarries located within the Susa valley.⁵³ In contrast, the Arch of Augustus at Aosta, was constructed entirely in local puddingstone. White marble elements in Turin at the Palatina Gate and the theatre were carved from Chianocco, quarried a short distance away in the valley of the Dora Riparia.⁵⁴ Where larger architectural elements carved from imported marble are present, they are mainly carved from Luna. For example, at Aosta, although the main structure of the Porta Praetoria was formed of puddingstone and its front was covered with a veneer of locally quarried Aymavilles marble, the entablature consisted of imported Luna marble.⁵⁵ Further south, at Augusta Bagiennorum, the theatre's *scaenae frons* was also decorated with columns and statues carved from Luna.⁵⁶ Although the trans-Appennine journey was economic enough for some larger architectural elements in white Luna marble to be transported into Northern Italy, they are present in the

Aegean and Asia Minor. Another possible reason for the supposed high quantity of *bardiglio* at Forlì may be the difficulty of accurately provenancing grey marble without using without petrographic and mineralogical analysis (Borghi et al. (2006), 60; Mariottini (1998), 23). Forlì's assemblage was not subject to such analysis, and *bardiglio* may have been used as the default identification for grey marble (Guarnieri (2013a), 87). The site's assemblage could, in fact, have a more varied provenance.

⁵¹ See Russell (2013), Chapter 5 for several case studies of the inland distribution of stone across the Roman Empire.

⁵² Russell (2018b), 253-54.

⁵³ Agostoni et al. (2017), 414; Betori et al. (2009); Borghi et al. (2009).

⁵⁴ Betori et al. (2009), 96.

⁵⁵ Betori et al. (2009), 97; Borghi et al. (2006).

⁵⁶ Rulli (2008), 14.

greatest quantities in areas closest to the passes.⁵⁷

In the east of the region, there is more evidence for the movement of stone for the carving of large architectural elements. Local stones still formed the basis of most structures, for example, the use of Aurisina at Aquileia and Padua or Bottocino at Brescia, but large architectural components that had travelled significant distances took a prominent place in the structural composition.⁵⁸ Brescia's forum was bordered by columns of Proconnesian marble, while the columns surrounding the Claudian forum at Verona were carved from a combination of *africano*, *bigio antico*, *cipollino*, and *giallo antico*.⁵⁹ Beyond Brescia, however, most prominent architectural elements at sites in the north-west of the region seem to have been carved from local lithotypes (e.g. the aforementioned columns of Musso in Milan). The cost of commissioning and transporting such large simply seems to have been too expensive for sites further inland from the Adriatic coast.

Aside from architectural elements, sarcophagi of imported white marble form another useful comparative dataset to explore patterns of stone distribution. Gabelmann quantified and mapped the distribution of sarcophagi in Northern Italy.⁶⁰ Sarcophagi of Pentelic marble, while well attested on the coast (particularly at Aquileia), had minimal penetration inland (see Figure 8.32). In contrast, sarcophagi of the 'Ravenna Type', carved from Proconnesian marble, had much wider inland distribution and have been discovered as far west as Pavia (see Figure 8.33). This mirrors the situation seen with revetment and floor tiles. Pentelic marble was barely attested in the region, while Proconnesian marble was often recovered in significant quantities. Of course, sarcophagi made of imported stone represent the high end of the market. For those who could not afford to be entombed in Proconnesian or Pentelic marble, local alternatives were available. A recent quantified study of sarcophagi from Pavia shows the reliance of the city's elite on regional materials for its tombs (see Figure 8.34).⁶¹ Of the thirty-one sarcophagi recovered, only four were carved from imported marble, three from Proconnesian, one from an unknown source. The rest were made from a mixture of granites and gneisses from Alpine quarries, alongside two 'local' lithotypes from sub-Alpine deposits.⁶² It is perhaps unsurprising that there are few examples of

⁵⁷ Gomez Serito (2019).

⁵⁸ Bonetto and Previato (2013); Destro (2015), 69-75; Kleineberg (2021); Pensabene (2015), 611-12.

⁵⁹ For Brescia see Sacchi et al. (2011), 122. Although these columns have been alternatively identified as *cipollino* and *pavonazzetto* by earlier publications (see Kleineberg (2021), n. 17). For Verona, see Bianco (2008), 211-14; Cavalieri Manasse (2008a), 298.

⁶⁰ Gabelmann (1973). See Russell (2013), 169-76 for discussion of the data.

⁶¹ Gorrini and Robino (2015).

⁶² The Alpine lithotypes present at Pavia were extracted at various points along the River Toce in the Val d'Ossala and at San Fedelino on the shores of Lake Mezzola (Gorrini and Robino (2015), 114). Many of the quarries were in close proximity to a navigable river or lake.

imported stone sarcophagi at Pavia, which, being located close to Tortona, seems to have represented the point that imports of Eastern Mediterranean stone and marble began to decline in quantity and diversity.

8.5 Conclusions

Although a very different material from the ceramic assemblages so far analysed, the distribution of decorative stone veneer in Northern Italy bears many similarities to amphorae and finewares. The region's geography played an important role in determining the origin of the lithotypes consumed within it, with the different requirements of each consumer balanced against the logistical and economic feasibility of transporting the available material suitable for the project. In the eastern and central parts of the region, the flat topography and proximity to the coast allowed sites to utilise a wide variety of imported decorative stone, primarily from the Eastern Mediterranean and Egypt and North Africa. Further inland, the situation became more complex, as mounting transport costs saw an increased reliance on Alpine stone in the north-west of the valley, and the dominance of Luna marble from the Ligurian coast in the west and south-west. Despite their distance from the coast, inland regions were still able to access a wide range of Mediterranean lithotypes. The fact that sites such as Aosta, which lay more than 650 km from the Adriatic coast, were still able to import Eastern Mediterranean and Egyptian and North African marble to decorate their buildings shows that cost did not deter sites from accessing imported marble. However, while cost did not prevent the use of Eastern and Egyptian and North African lithotypes, it did limit the variety available and its primary application to veneer.

Although revetment forms only part of the picture of regional stone trade, the overarching pattern that it presents is supported by the distribution of imported architectural elements and sarcophagi. Transport costs formed a major factor in limiting the inland distribution of these items, although some, such as Proconnesian sarcophagi, achieved a remarkable level of penetration. Beyond the confluence of the Ticino and Po at Pavia, there are few examples of such expensive and bulky objects in Eastern and Egyptian and North African lithotypes, with locally quarried stone and marble utilised to a greater extent. However, it is important to remember, that even in areas that had the greatest access to imports, lower quality, local stone formed the basis of construction projects.

The presence of both imported and regional decorative stone across Northern Italy reflects varying levels of trade and investment in construction, sculpture, and sarcophagi in Northern Italy. The patterns and distribution of decorative stone

explored in this chapter form a valuable counterpart to those seen in the amphora and fineware data, allowing a more varied and in-depth picture of inland trade to develop. In the final part of this thesis, the three datasets of amphora, finewares, and stone are brought together, alongside the network model, to explore detailed questions on inland transport and trade in Northern Italy.

Part 3: Conclusions

Chapter 9

River Valleys, Trade, and Inland Economies

The importance of river valleys in facilitating inland connectivity has long been accepted in scholarship, yet prior studies have generally remained unquantified and often limited to distribution maps.¹ In comparison, this thesis has utilised network analysis and three distinct quantified material datasets to demonstrate how fluvial systems and wider transport infrastructure were integral to the distribution of goods within Northern Italy. Part One of the thesis detailed the creation of two network models to analyse the cost and time of transport in Northern Italy, while Part Two examined three sets of material data geographically and chronologically across the study area. The final part of this thesis unites the network model and material analyses, combining their results to explore wider questions regarding inland trade in the Roman period.

In many cases, as shown below, there is a remarkable level of overlap between the distribution of different material types and the cost surfaces generated by the network models. The importance of fluvial networks to inland trade is readily apparent, although this study also highlights their limitations. As will be discussed below, overland trade, the majority of which took place across mountain ranges, seems to have played a major role in supplying certain areas of Northern Italy. While the results of the analyses demonstrate the key role of geography in determining the cost of transport and the subsequent distribution of material within inland regions throughout the Roman period, they also suggest a wider array of other factors played a significant part in how material circulated. These include hidden costs, the vagaries of the market, and consumer choice, alongside availability and supply, things that the network model could not account for.²

¹ For example, Bruno (2005a); Gabucci (2017); Kenrick (2000); Lindhagen (2009); van den Berg (2012).

² The contrasting ways in which goods were consumed, especially the distinction between

Overall, the results of the analyses undertaken in this thesis challenge long-held orthodoxies that inland sites were geographically isolated and had access to a more limited range of imports than those on the coast.³ Although it is undeniable that inland areas faced additional obstacles to coastal sites when it came to trade, they were not excluded from wider Mediterranean markets; even regions at the furthest distance from the coast could possess imports in significant quantities.

This chapter unites the results of the network and material analyses. The groups of sites found during the hierarchical clustering are mapped onto the cost surfaces produced by the network analysis. Material distributions are compared with transport cost and time for both ‘regular’ and ‘heavy’ cargoes, and the results summarised. The importance of geography in the distribution of material in inland regions is explored, particularly rivers and mountain ranges, while the role of factors and costs not present in the network model are also analysed. Contrasts in the distribution and provenance of amphorae, finewares, and decorative stone are highlighted, alongside the reasons for why this might be, while the chronological evolution of trade patterns is also discussed. In addition, the question of what Northern Italy may have exported is investigated. Finally, the chapter examines the wider impact of the results on broader understandings of inland economies. The locations of sites mentioned within this chapter can be viewed in Figure 9.1.

9.1 Zones of Consumption

Across the material analysis, when sites were hierarchically clustered based on the provenance of their assemblages, three distinct geographic clusters routinely formed (with some overlap between sites). These broadly encompassed the coastal plain and valley floor, the north-west Po valley and the Alpine foothills, and the west and south-west of the Po valley. This pattern was at its most pronounced during the first-second centuries AD, and although the lower quality of data from the Late Republic and third-fifth centuries AD meant the distribution was less clear, the overall trend remained. The section below outlines each of these geographic zones, the material trends identified within them, and how their distribution relates to the time and cost of transport.

ceramics and stone, also served to determine the provenance and circulation of each material type within Northern Italy.

³ Bonifay (2004), 451–2; Horden and Purcell (2000), Chapters 4 and 5; Tchernia (2016), 90–93; Temin (2001), 179–81.

Site	Average cost from Adriatic Ports (kg wheat)	Average cost from Ligurian Ports (kg wheat)	Difference in cost (kg wheat)	Cheapest origin
Adria	88	584	496	Adriatic
Bologna	143	615	472	Adriatic
Brescia	221	621	400	Adriatic
Calvatone	297	661	364	Adriatic
Cremona	219	512	293	Adriatic
Este	102	612	510	Adriatic
Forlì	267	835	568	Adriatic
Julia Concordia	81	644	563	Adriatic
Modena	170	608	438	Adriatic
Oderzo	121	663	542	Adriatic
Padua	87	608	521	Adriatic
Reggio Emilia	288	653	365	Adriatic
Verona	151	662	511	Adriatic
Vicenza	112	630	518	Adriatic

Table 9.1: Average transport costs in kg wheat for regular cargoes from the Adriatic and Ligurian coasts to sites in the coastal plain and central valley.

9.1.1 The Coastal Plain and Central Valley

The first (and often largest) group of sites to form during the hierarchical clustering consisted of those located in the coastal plain and central valley (see Figures 9.2, 9.3, 9.4, and 9.5). Sites in this area could be reached for an average transport cost of under 300 kg wheat from the Adriatic coast, making them the most accessible from a price standpoint (see Table 9.1).⁴ Many could be reached for far less, with those possessing the best connections, such as Adria, Julia Concordia, and Padua, averaging transport costs of less than 100 kg wheat from the Adriatic ports. Transport costs to sites in this area of the region from the Ligurian ports, on the other hand, averaged between 500 and 700 kg wheat. For the sites of Adria, Julia Concordia, and Padua, average transport costs were upwards of 500% more expensive from the Ligurian, rather than the Adriatic, coast. Even at sites in the centre of the valley such as Calvatone and Cremona, transport costs were upwards of 100% more expensive to reach from the Ligurian coast than the Adriatic coast. This accounts for the relative paucity of material from the Western Mediterranean present in assemblages from the coastal plain and central valley. Travel time was uniformly quicker from the Adriatic coast for sites in this cluster, with the exception of two sites, Brescia and Cremona, for which it was faster to travel from the Ligurian coast (see Table 9.2).

⁴ The costs presented here are averages taken for journeys originating from the four Adriatic and four Ligurian ports within the network model outlined in Chapter 4. Transport costs could be lower or higher from the individual ports. The costs of each individual journey were calculated using the Plot Route function in the ArcGIS Network Analyst Suite, with kg/wheat selected as the cost.

Site	Average travel time from Adriatic Ports (hours)	Average travel time from Ligurian Ports (hours)	Difference in travel time (hours)	Quickest origin
Adria	56	159	103	Adriatic
Bologna	67	131	64	Adriatic
Brescia	123	122	1	Ligurian
Calvatone	96	102	6	Adriatic
Cremona	107	93	14	Ligurian
Este	68	146	78	Adriatic
Forlì	58	157	99	Adriatic
Julia Concordia	64	200	136	Adriatic
Modena	78	117	39	Adriatic
Oderzo	71	191	120	Adriatic
Padua	69	169	100	Adriatic
Reggio Emilia	88	169	91	Adriatic
Verona	88	126	37	Adriatic
Vicenza	69	145	76	Adriatic

Table 9.2: Average transport time in hours for regular cargoes from the Adriatic and Ligurian coasts to sites in the coastal plain and central valley.

For sites in this part of the region, although their proximity to ports and the density of the transport network should theoretically have afforded them a greater choice of imported amphora-borne goods and finewares, ceramic assemblages were dominated by material from a single provenance. For amphorae, this consisted of vessels produced on the Adriatic littoral, while for finewares, Northern Italic Terra Sigillata (NITS) formed the main component of assemblages. The dominance of material from a single provenance meant that there was very little diversity in the vessel types present across assemblages within the cluster. This was most noticeable in the amphora data, with Dressel 6A and 6B vessels forming the major component of assemblages. The pattern was less pronounced with the fineware data, although the overall trend remained. The ceramic assemblages of Adriatic port sites often exhibited greater diversity in both their provenance and vessel composition than sites in their hinterlands, meaning they did not cluster together.⁵ Sites closest to ports, such as Bologna, Forlì, Oderzo, and Padua, do not seem to have shared their diversity, continuing to be dominated by ceramic material from a single provenance.

The situation was more complex for stone assemblages. Assemblages from the coastal plain and central valley were composed of decorative stone from multiple provenances, although their main origin could be broadly defined as the Eastern Mediterranean. Stone from Central Italy (south of the Apennines) was almost

⁵ The higher diversity, both in provenance and vessel form, at port sites reflects their role of as centres of import and export. Although Adriatic port sites exhibited the highest diversity for vessel forms, a limited number of provenances were attested. It is probable some of the vessel forms attested represent the movement of people or sporadic cargoes, rather than sustained trade.

Site	Average cost of heavy cargoes from Adriatic Ports (kg wheat)	Average cost of heavy cargoes from Ligurian Ports (kg wheat)	Difference in cost (kg wheat)	Cheapest origin
Adria	239	1031	792	Adriatic
Bologna	297	1062	767	Adriatic
Brescia	287	978	691	Adriatic
Calvatone	451	1108	657	Adriatic
Cremona	373	959	586	Adriatic
Este	278	1059	781	Adriatic
Forlì	355	1282	927	Adriatic
Julia Concordia	137	1001	864	Adriatic
Modena	325	1056	731	Adriatic
Oderzo	248	1110	862	Adriatic
Padua	156	965	809	Adriatic
Reggio Emilia	444	1051	647	Adriatic
Verona	307	1109	802	Adriatic
Vicenza	268	1077	809	Adriatic

Table 9.3: Average transport costs in kg wheat for heavy cargoes from the Adriatic and Ligurian coasts to sites in the coastal plain and central valley.

entirely absent from these assemblages, likely due to the cost of transporting it into the region. The cost of transporting heavy cargoes from the Ligurian coast, across the Apennines and then across the valley floor, was between 600% and 900% more expensive than from the Adriatic ports (see Table 9.3). As with the ceramic assemblages, travel time was uniformly quicker for heavy cargoes from the Adriatic coast, except in the case of Cremona (see Table 9.4). In contrast to the ceramic assemblages, stone assemblages from the coastal plain and central valley scored averagely for the diversity of the lithotypes present within them, although port sites again scored highest of all. There was also much greater similarity in the composition of stone assemblages at Adriatic ports and the sites in their immediate hinterland.

The cluster of ceramic and stone assemblages in the coastal plain and central valley covered a large part of the study area. The level, flat ground and the density of the river network enabled goods arriving at the Adriatic ports to penetrate a significant distance inland for comparatively low transport costs. The same was true of ceramics produced within the region, with low transport costs allowing NITS to circulate across the valley floor and coastal plain (although the stamp analysis suggests that the majority of NITS consumed within the region travelled over short distances (see Section 7.5.1)). The similarity and homogeneity of the ceramic assemblages across this cluster is striking, with sites such as Calvatone and Cremona, located several hundred kilometres inland, having near identical assemblages to those on the coast. For ceramic assemblages, vessels produced in the Adriatic and within the region dominated (almost to the ex-

Site	Average travel time of heavy cargoes from Adriatic Ports (hours)	Average travel time of heavy cargoes from Ligurian Ports (hours)	Difference in travel time (hours)	Quickest origin
Adria	73	186	113	Adriatic
Bologna	82	158	76	Adriatic
Brescia	163	171	8	Adriatic
Calvatone	111	127	16	Adriatic
Cremona	123	118	5	Ligurian
Este	83	171	88	Adriatic
Forlì	73	184	111	Adriatic
Julia Concordia	75	249	174	Adriatic
Modena	93	143	50	Adriatic
Oderzo	101	217	116	Adriatic
Padua	107	218	111	Adriatic
Reggio Emilia	103	132	29	Adriatic
Verona	103	150	47	Adriatic
Vicenza	89	170	81	Adriatic

Table 9.4: Average transport time in hours for heavy cargoes from the Adriatic and Ligurian coasts to sites in the coastal plain and central valley.

clusion of all other provenances within the amphora data). Northern Italic and Adriatic goods travelled the shortest distance (and presumably incurred minimal additional costs) to reach their point of consumption within the region. Rather than take advantage of imports from further away, sites in the coastal plain and central valley chose to consume the most readily available (and presumably the cheapest) goods. The opposite was true for stone assemblages, which contained a wide variety of provenances and lithotypes. The diversity of lithotypes found in this part of the region (compared to the more restricted selection seen further inland), reflects the higher cost of transporting heavy cargoes (such as stone), which served to limit its distribution. This ensured the greatest quantities and diversity of imported decorative stone were present closest to their point of entry to the region.⁶ As stone was prized for its ornamental qualities, having a greater number of lithotypes allowed a more varied decorative scheme, alongside the prestige this afforded. Consequently, sites in this part of the region made full use of the range of decorative stone available, while locations further inland were forced to contend with less choice (see below).

9.1.2 The North-West Po Valley and Alpine Valleys

The second group of sites to form during the hierarchical clustering consisted of those located in the north-west of the Po valley and the Alpine valleys (see

⁶ The expertise needed to prepare floor and revetment panels was likely concentrated in these coastal sites, the points where imported decorative stone entered the region (Russell (2013), 167-68).

Site	Average cost from Adriatic Ports (kg wheat)	Average cost from Ligurian Ports (kg wheat)	Difference in cost (kg wheat)	Cheapest origin
Cividate Camuno	611	1010	399	Adriatic
Como	322	616	294	Adriatic
Industria	368	526	158	Adriatic
Milan	303	527	224	Adriatic
Novara	461	620	159	Adriatic
Trento	631	1143	512	Adriatic
Vercelli	357	516	159	Adriatic

Table 9.5: Average transport costs in kg wheat for regular cargoes from the Adriatic and Ligurian coasts to sites in the north-west of the Po valley and the Alpine valleys.

Site	Average travel time from Adriatic Ports (hours)	Average travel time from Ligurian Ports (hours)	Difference in travel time (hours)	Quickest origin
Cividate Camuno	154	153	1	Ligurian
Como	173	129	44	Ligurian
Industria	173	96	77	Ligurian
Milan	150	101	49	Ligurian
Novara	158	103	55	Ligurian
Trento	118	164	46	Adriatic
Vercelli	161	104	57	Ligurian

Table 9.6: Average transport time in hours for regular cargoes from the Adriatic and Ligurian coasts to sites in the north-west of the Po valley and the Alpine valleys.

Figures 9.6, 9.7, and 9.8). Most sites in this part of the region could be reached from the Adriatic coast for an average cost of under 400 kg wheat, while average transport costs from the Ligurian ports were mostly under 700 kg wheat (see Table 9.5). Although it was still significantly cheaper for goods to travel from the Adriatic coast, the difference in cost between the Adriatic and Ligurian ports was not as great as it had been for sites further east. Transport costs from the Ligurian coast, however, still came close to double those from the Adriatic. The sites with the most expensive transport costs were those located within the Alpine valleys: Cividate Camuno, and Trento. Neither of these sites was located on the navigable segment of a river and the journey to both involved overland transport over medium gradients for large sections of travel. With the exception of Trento, it was faster to travel from the Ligurian ports to sites in this part of the region (see Table 9.6).

For sites in the north-west of the Po valley, Adriatic amphorae and NITS continued to form the major components of ceramic assemblages. Although the Adriatic still accounted for the main provenance of amphorae, vessels from this zone of production appeared in lower quantities than at sites from the coastal plain and central valley. Eastern amphorae, particularly the Camulodunum 184,

Site	Average cost of heavy cargoes from Adriatic Ports (kg wheat)	Average cost of heavy cargoes from Ligurian Ports (kg wheat)	Difference in cost (kg wheat)	Cheapest origin
Cividate Camuno	897	1588	691	Adriatic
Como	401	974	573	Adriatic
Industria	522	974	452	Adriatic
Milan	357	873	516	Adriatic
Novara	616	1068	55	Adriatic
Trento	847	1649	802	Adriatic
Vercelli	512	963	451	Adriatic

Table 9.7: Average transport costs in kg wheat for heavy cargoes from the Adriatic and Ligurian coasts to sites in the north-west of the Po valley and the Alpine valleys.

appear in greater numbers. Amphora-borne goods from the Western Mediterranean, however, continued to appear in only marginal quantities, despite the area's closer proximity of the Ligurian ports. A similar situation is seen with finewares, especially in the Alpine foothills and valleys. At Cividate Camuno, Como, and Milan, although NITS remained the dominant component of assemblages, Gallic Terra Sigillata (GTS) appeared in significant quantities. The more varied provenance of ceramic assemblages is reflected in the diversity of their vessel forms, which is somewhat higher (although marginally so), than sites closer to the Adriatic coast.

As with the ceramic assemblages, it was still significantly cheaper for heavy cargoes to travel from the Adriatic coast, with the difference in cost between the Adriatic and Ligurian seabords remaining approximately double despite the more complex logistics (see Table 9.7). Travel time remained shorter for heavy cargoes from the Ligurian coast with the exception of Cividate Camuno and Trento (see Table 9.8). Stone assemblages in the north-west of the Po valley exhibited a very different character to those in the central valley and coastal plain. Although Eastern Mediterranean lithotypes were still present, in particular those from Asia Minor, locally quarried stone from the Alps made up a substantial portion of the assemblages at Como, Milan, and Vercelli; the only other site to include Alpine lithotypes in similar quantities was Aosta in the west. Stone assemblages from sites in this part of the region also possessed the highest scores for diversity outside of the Adriatic ports.

The point at which the transport costs for goods originating from the Adriatic coast began to impact on their distribution seems to have begun in this part of the region. Increased transport costs saw the assemblages of sites in the north-west begin to take on a different character to those in the coastal plain and central valley, echoing the situation seen in material assemblages at sites in the south-west (discussed below). The network model suggests that the cost of reaching sites in

Site	Average travel time of heavy cargoes from Adriatic Ports (hours)	Average travel time of heavy cargoes from Ligurian Ports (hours)	Difference in travel time (hours)	Quickest origin
Cividate Camuno	204	212	8	Adriatic
Como	234	188	46	Ligurian
Industria	189	128	61	Ligurian
Milan	189	150	39	Ligurian
Novara	188	128	60	Ligurian
Trento	147	194	47	Adriatic
Vercelli	176	130	46	Ligurian

Table 9.8: Average transport time in hours for heavy cargoes from the Adriatic and Ligurian coasts to sites in the north-west of the Po valley and the Alpine valleys.

the north-west from the Adriatic ports was almost triple that of sites in the coastal plain and central valley; well over 300 kg wheat per tonne. For sites located away from the river network, although still on the valley floor, such as Novara, this cost rose to over 600 kg wheat. Sites located within the Alpine foothills and valleys, such as Cividate Camuno and Trento, had similar assemblage compositions to those in the north-west. While theoretically located closer to the Adriatic ports than their western counterparts, their position away from the water network and the gradients faced by overland transport increased the cost of reaching them.

Increasing transport costs seem to have made goods from a wider array of provenances more competitive against those originating from within or directly adjacent to the region, which began to complement Adriatic amphorae and NITS in the ceramic assemblages. For amphorae, vessels from the Eastern Mediterranean began to appear in appreciable quantities, while for finewares, GTS and Central Italic Terra Sigillata (CITS) were present in roughly equivalent quantities to NITS. Interestingly, the origin of GTS at sites in the north-west and Alpine valleys seems to have been neither the Adriatic nor Ligurian ports but rather a trans-Alpine journey from production sites in Gaul. GTS crossing the Alps seems to have been competitive in very specific contexts, as it does not appear in significant quantities on the valley floor. For stone assemblages in the north-western valley, located at the furthest distance from both the Adriatic and Ligurian ports, the costs and logistics of transporting heavy cargoes seems to have resulted in an increased reliance on locally quarried decorative stones. The use of both local decorative stone (not utilised in significant quantities in the east of the region), alongside imported lithotypes, was responsible for the high diversity within decorative stone assemblages from this area.

For all the material discussed in this cluster, it is important to highlight that, although transport costs seem to have made goods from extra-regional provenances more (in the case of ceramics) and less (in the case of decorative stone)

Site	Average cost from Adriatic Ports (kg wheat)	Average cost from Ligurian Ports (kg wheat)	Difference in cost (kg wheat)	Cheapest origin
Acqui Terme	537	441	96	Ligurian
Alba	393	552	159	Adriatic
Alessandria	341	500	159	Adriatic
Aosta	802	961	159	Adriatic
Augusta Bagiennorum	489	502	13	Adriatic
Chieri	486	645	159	Adriatic
Ivrea	394	553	159	Adriatic
Libarna	442	321	121	Ligurian
Tortona	322	440	122	Adriatic
Turin	390	548	158	Adriatic

Table 9.9: Average transport costs in kg wheat for regular cargoes from the Adriatic and Ligurian coasts to sites in the west and south-west of the Po valley.

competitive, they did not drastically change the prevailing trends in material distribution. The Adriatic still formed the main provenance of amphora-born goods, NITS still appeared in significant quantities, and decorative stone from the Eastern Mediterranean still formed the largest overall component of stone assemblages. The east-west axis of trade remained dominant and imports from the Western Mediterranean, save GTS in some unique circumstances, remained uncompetitive given the significant transport costs from the Ligurian ports. It was only in the final cluster of sites in the west and south-west of the Po valley that the composition of material assemblages radically changed.

9.1.3 The West and South-Western Po Valley

The final group of sites to form during the hierarchical clustering consisted of those located in the west and south-west of the Po valley (see 9.9 and 9.10, alongside Figure 9.7 from the previous section). Most sites in this part of the region could be reached from the Adriatic coast for an average cost of under 500 kg wheat, while average transport costs from the Ligurian ports were mostly under 600 kg wheat (see Table 9.9). The major exception to this was Aosta, which, like Cividate Camuno and Trento in the previous cluster, incurred far greater transport costs due to its position within the upper Alpine valleys. The difference in price between inland transport from the Adriatic and Ligurian coasts was at its lowest in this cluster. For many sites in this part of the region, the difference in transport price between the two coasts was consistent around the figure of 159 kg wheat. It was uniformly quicker to travel from the Ligurian ports than the Adriatic ports to reach sites in this cluster (see Table 9.10).

For the most part, the model suggested that it remained cheaper to transport goods to this area of the region from the Adriatic, rather than the geographically

Site	Average travel time from Adriatic Ports (hours)	Average travel time from Ligurian Ports (hours)	Difference in travel time (hours)	Quickest origin
Acqui Terme	163	62	101	Ligurian
Alba	178	78	100	Ligurian
Alessandria	156	70	86	Ligurian
Aosta	213	146	67	Ligurian
Augusta Bagiennorum	189	69	120	Ligurian
Chieri	182	91	91	Ligurian
Ivrea	180	113	67	Ligurian
Libarna	155	50	105	Ligurian
Tortona	145	60	85	Ligurian
Turin	184	92	92	Ligurian

Table 9.10: Average transport time in hours for regular cargoes from the Adriatic and Ligurian coasts to sites in the west and south-west of the Po valley.

closer Ligurian coast. Indeed, it is striking that only two sites in the study area had lower transport costs from the Ligurian ports than the Adriatic ones: Acqui Terme and Libarna. From the Adriatic coast, transport costs to sites within this cluster were similar to those of sites in the north-west (see, for example, Industria, Novara, and Vercelli above), however, ceramic assemblages from this part of the region had a markedly different composition. Products from the Western Mediterranean, such as Gallic, Iberian, and Tyrrhenian amphorae, and CITS and GTS, were concentrated in the west and south-west of the Po valley.⁷ Western Mediterranean amphorae especially achieved minimal penetration further east and to the north (see Figure 9.11). For amphorae, vessels with an Adriatic provenance dropped below 50% in each of the assemblages, while the combination of CITS and GTS made up a greater portion of fineware assemblages than NITS (echoing the situation seen at sites in the Alpine foothills and valleys in the previous cluster). Sites in the west and south-west achieved some of the highest diversity scores and had the lowest level of vessel overlap within their ceramic assemblages, reflecting the more varied provenances of their material.

When it came to heavy cargoes, the network model suggested it was uniformly cheaper to transport them from the Adriatic, rather than the Ligurian, ports (see Table 9.11). Yet, as with the ceramic assemblages, the decorative stone present at sites in the west and south-west primarily reflected a Western Mediterranean, rather than an Eastern Mediterranean, provenance. In particular, Central Italic lithotypes made up a significant portion of stone assemblages within this cluster but had very little penetration further north and east (see Figure 9.11).⁸ This

⁷ While GTS found at sites in the west of the region likely also entered the region via a trans-Alpine route, GTS at sites in the south-west of the Po valley may have entered via the Alpine or crossed the Ligurian passes after a maritime journey.

⁸ The only exception to this was the stone assemblage at Forlì, although the Central Italic provenance of the ‘*bardiglio*’ marble found at the site is somewhat suspect. See Section 8.4.3

Site	Average cost of heavy cargoes from Adriatic Ports (kg wheat)	Average cost of heavy cargoes from Ligurian Ports (kg wheat)	Difference in cost (kg wheat)	Cheapest origin
Acqui Terme	741	771	30	Adriatic
Alba	537	695	428	Adriatic
Alessandria	609	839	230	Adriatic
Aosta	1132	1583	451	Adriatic
Augusta Bagiennorum	636	939	303	Adriatic
Chieri	675	1127	452	Adriatic
Ivrea	548	1000	452	Adriatic
Libarna	608	576	32	Adriatic
Tortona	477	707	230	Adriatic
Turin	543	995	452	Adriatic

Table 9.11: Average transport costs in kg wheat for heavy cargoes from the Adriatic and Ligurian coasts to sites in the west and south-west of the Po valley.

Site	Average travel time of heavy cargoes from Adriatic Ports (hours)	Average travel time of heavy cargoes from Ligurian Ports (hours)	Difference in travel time (hours)	Quickest origin
Acqui Terme	178	93	85	Ligurian
Alba	194	113	81	Ligurian
Alessandria	172	101	71	Ligurian
Aosta	244	189	55	Ligurian
Augusta Bagiennorum	206	113	93	Ligurian
Chieri	197	125	72	Ligurian
Ivrea	196	142	54	Ligurian
Libarna	171	82	89	Ligurian
Tortona	161	90	69	Ligurian
Turin	199	127	72	Ligurian

Table 9.12: Average transport time in hours for heavy cargoes from the Adriatic and Ligurian coasts to sites in the west and south-west of the Po valley.

mirrors the situation with the ceramic assemblages. The stone assemblage at Aosta also included the greatest quantity of Alpine lithotypes within the study area, echoing the high proportion seen at Como, Milan, and Vercelli. Assemblages of decorative stone recorded the lowest scores for diversity in this cluster, a result of the high quantities of white Luna marble contained within them. It remained far quicker to transport heavy cargoes from the Ligurian, rather than the Adriatic, ports (see Table 9.12).

Sites in the west and south-west of the Po valley were located close to the navigable endpoints of the region's rivers, within the Langhe, Monferrato, and Colline del Po hills, or, in the case of Aosta, high in Alpine valleys. Sites in the south-west of the region, Acqui Terme, Alba, Alessandria, Augusta Bagiennorum, Libarna, and Tortona, were amongst those that could be reached from

for further discussion.

the Ligurian coast for the least cost. However, only Acqui Terme and Libarna, the sites closest to the Ligurian coast, could actually be reached for a lower cost from the Ligurian, rather than the Adriatic, ports. If cost was the sole factor in determining the distribution of goods, then one would expect to see items with a predominantly Adriatic and Eastern Mediterranean provenance make up the assemblages in this cluster (in a similar fashion to sites in the north-west). However, this was not the case. Western Mediterranean imports made up a significant proportion (often more than 40%) of the material assemblages of these sites. The quantity of stone originating from Central Italy appearing in the south-west, despite costing significantly more to transport across the Apennines than decorative stone travelling from the Adriatic ports, was particularly striking. As highlighted above, the difference in transport costs between the opposing seaboard was at its lowest here, consistently averaging around 159 kg wheat for one tonne of regular cargo. While still a significant difference, fluctuations in cost as a result of other factors (discussed in further detail below) may have reduced this further. Alternatively, elements other than cost may have played a role in the selection of goods in this part of the region (see below). In the case of stone transport, the logistics, particularly distance and time, may have been a more important consideration than cost. A longer journey over a greater distance (potentially including multiple transshipments) increased the risk of breakages or loss of the cargo, may have made the shorter and quicker trans-Apennine route more appealing.⁹ Regardless, Western Mediterranean imports were uniquely competitive in the west and south-west of the Po valley in a way unmatched elsewhere in Northern Italy.

Despite the significant portion of Western Mediterranean goods in their assemblages, the east-west axis of trade from the Adriatic coast along the Po valley remained important for sites located in the west and south-west of the region. The Adriatic persisted as the single largest provenance of amphora-borne goods, even at sites where the network model suggested transport was cheaper from the Ligurian coast. The distinction in material between sites in the south-west of the Po valley and Ligurian coast is further demonstrated by the failure of the Ligurian ports to cluster with sites in this part of the region during the amphora analysis. They instead formed a separate group when subjected to hierarchical clustering. For finewares, NITS remained the dominant red-slipped ceramic at sites within the west and south-west of the Po valley, with the exception of Acqui Terme and Augusta Bagiennorum. While these two were the closest to the Ligurian coast

⁹ The proximity of the quarries at Luna to sites in the south-west of the Po valley would also have made it easier for commissioners to correspond directly with the quarry, removing the need for middle men.

and contained high quantities of CITS and GTS, they did not cluster with the single Ligurian port within the fineware analysis (Luna). Instead, Luna's assemblage clustered with Bologna and Modena in the eastern valley. A quantified stone assemblage was lacking for the Ligurian coast, however, the quantity of white Luna marble present in the west and south-west suggests the Apennines may have formed an equally important axis for the stone trade as the Po valley.

9.2 Inland Trade: Costs and other factors

The uniting of the network and material analyses demonstrated several things about inland trade within Northern Italy. First, that the arrangement of ceramic material clusters had a far greater correspondence to transport cost rather than transport time, suggesting this was the dominant factor affecting distribution.¹⁰ The picture was more complex for heavy cargoes. Transport cost seems to have played an important part in their distribution but in, some cases, transport time may have been a more important consideration. Second, the region's geography played a key role in influencing transport costs (both positively and negatively), and the corresponding distribution of goods inland. Finally, the joining of the two analyses highlighted key differences between the network model and material evidence, emphasising that factors beyond transport cost and time may have also influenced the distribution of goods. The results of the analyses are discussed in further detail below.

9.2.1 Geography: Rivers and Mountains

The geography of Northern Italy played a crucial role in determining the cost of transport. Geography and cost are intrinsically linked, with the topography and fluvial network having some of the greatest impact on both transport cost and time.¹¹ Both the network model and the material analysis demonstrated the prominence of the Po river system in the distribution of goods across the region. The importance of the river network to inland trade is reflected by the widespread investment in fluvial infrastructure across the region during the first century AD (see Section 3.1.5). Even prior to this investment, the river network played a

¹⁰ This is, however, not to say that time had no bearing on how goods moved. Perishable foodstuffs such as fresh fruit, vegetables, and meat would have a short window for transport before spoiling, making time an important factor in their movement. However, these likely travelled over short distances. See, for example, the concentration of sites engaged in the production of perishables in Rome's *suburbium* (Marzano (2007), 108-09; Patterson et al. (2020), 179-82; Wilson (2009c)).

¹¹ Combes et al. (2008), 5-10; Limão and Venables (2001); McCormick (2001), 64; Rodrigue and Notteboom (2020).

crucial role in the distribution of Adriatic amphorae in the Late Republic. The density of the water network, which, through the inclusion of the para-littoral canals and Adriatic lagoon system, also included the rivers in the Veneto, meant that sites on the Po-Veneto plain were never more than 15 km from a navigable river. The density of the water network in Northern Italy and its role in shaping inland trade echoes the situation seen in ancient Gaul, in particular along the Rhône and its tributaries. Gaul received extensive praise in the ancient sources for the breadth of its navigable river network, with the Rhône providing the main inland trade corridor from the Mediterranean.¹² Both the Po and the Rhône contained a high volume of water and a fast current, and both possessed large and important tributaries that broadened their navigable extents to areas beyond their main channels.¹³ Water traffic on the Po and Rhône river networks also saw extensive organisation in the form of *collegia nautarum*, attesting to the importance of transport along these waterways (see Section 3.1.1).

At a technical level, the areas furthest ‘inland’, i.e., those equidistant from either coastline, were located in the middle of the Po valley. Finds assemblages from these sites, despite their distance from both the Adriatic and Ligurian coasts, continued to be dominated by Adriatic amphorae and decorative stone from the Eastern Mediterranean, with Western Mediterranean goods appearing in minimal quantities. The availability of the Po river network and the barrier of the Apennines to the Ligurian coast created a scenario of imperfect competition between the Adriatic and Ligurian ports.¹⁴ This allowed imports arriving from the Adriatic ports to penetrate much further upriver in significant quantities before transport costs affected their distribution. Rivers also allowed products manufactured within the region, such as NITS, to widely circulate within the coastal plain and valley floor, facilitating both short and long-distance trade. Aside from the benefits of the river system itself, the level ground of the valley floor also served to reduce overland transport costs. Although there was a noticeable rise in the cost of transport to sites not located directly on rivers (e.g. Chieri or Novara), their material assemblages often did not significantly differ from those with fluvial connections, which served as a springboard for trade to sites in their immediate vicinity. Relatively low transport costs also served to account for the uniformity of assemblages across much of the valley floor and coastal plain, often

¹² Pliny, *Natural History* 3.33; Strabo, 4.1.2-14.

¹³ For the Rhône, the largest were the Isère and the Saône, the latter playing a crucial role in accessing the interior and the German *limes* due to its proximity with the headwaters of the Meuse and Moselle (Campbell (2012), 265, 271; Franconi (2014), 64-66, Chapter 7; Leveau (1999)). Both the Po and the Rhône also needed the excavation of canals to bypass the treacherous waters at their mouths (see Section 3.1.2).

¹⁴ Combes et al. (2008), 31-42; Sheppard (2006), 14-16.

dominated by goods from a single provenance produced either in the region or adjacent to it.

Although river transport played a crucial role in facilitating trade between coastal and inland regions, it was not without its limitations. In the north-west, west, and south-west of the region, sites contained material from Western Mediterranean markets that had entered Northern Italy overland via trans-Alpine and trans-Apennine passes. The material analysis confirmed the importance of overland, trans-mountain trade within Northern Italy, with the viability of trans-Alpine routes supported by the presence of significant quantities of GTS at sites within the Alpine passes and the west of the Po valley. The importance of trans-mountain routes was most apparent in the south-west of the region, where the trans-Apennine passes between the Ligurian coast and the Po valley formed a particularly busy trade corridor.¹⁵

The viability of trans-Apennine routes and the quantity of Western Mediterranean material in the west and south-west is in part a reflection of the unique economic geography of the Po-valley. The upper river valley, the area furthest from the river's mouth on the Adriatic coast, was only a short distance from another coastline. Although separated by a mountain range, the close proximity provided access to alternative markets via the Ligurian ports and a greater range of choice for consumers. The other river valley in the Roman world that shares these characteristics is that of the Ebro, in the Iberian Peninsula. The river's mouth flows into the Mediterranean but its headwaters are close to the Atlantic, separated from it by the Cantabrian Mountains (see Figure 9.12). Several ports are known on Spain's northern Cantabrian coast such as Amanun Portus/Flaviobriga, Oiasso, and Portus Victoriae (modern Castro-Urdiales, Irun, and Santander respectively) and the Atlantic formed an important trade route from the Mediterranean to Britain, Northern Gaul, and the Rhine frontier.¹⁶ It is possible that sites in the upper Ebro valley could have utilised these ports to complement trade connections along the river to the Iberian coast and Western Mediterranean, in a similar manner to sites in the west and south-west of the Po valley.

Unfortunately, the upper Ebro has not seen a similar level of investigation

¹⁵ For more information of trans-Apennine trade between the Ligurian coast and Po valley see Bruno (1998), Cera (2000); and Melli (2004). The logistical challenges behind transporting goods across these mountains were considerable. All trans-mountain journeys were overland, and many more wagons, hauliers, and beasts of burden would have been needed to transport the equivalent amount of cargo that could be carried by a river vessel (see Section 4.2).

¹⁶ Fernández Ochoa and Morillo (2010); Morillo et al. (2016). It is uncertain whether ships travelling north along the Atlantic façade took a straight route across the Bay of Biscay from Cape Finistere to the Pointe du Raz or hugged the Cantabrian coast and Côte d'Argent. The former would have bypassed ports close to the headwaters of the Ebro.

to its lower and middle valley, making comparisons between the coastal and inland sites challenging. The absence of major producers along the Atlantic coast that might leave an archaeologically visible product to trace adds further difficulties in tracking the intensity of this trade. Furthermore, many of the amphorae travelling along the Atlantic Façade, such as Dressel 20 and Haltern 70, were produced in Baetica, with the Ebro valley via the east coast of the Iberian peninsula providing a more direct route to reach the upper valley than going around the western coast.¹⁷ Indeed, sites in the lower and middle Ebro were dominated by ceramic materials produced in its immediate vicinity, principally amphorae and finewares originating from the Iberian coast and within the valley, echoing the situation within Northern Italy.¹⁸ The presence of GTS from the workshop at Montans at sites in the upper Ebro and along the Cantabrian coast provides some tenuous evidence of overland trade between the two, but without further study and quantification it is impossible to state its significance.¹⁹

The importance of an alternate maritime market is readily apparent in the material assemblages of sites in the west and south-western Po valley. Despite having similar transport costs from the Adriatic coast to sites in the north-west of the Po valley, the availability of an alternate market provided a greater degree of choice to consumers in the south-west. This resulted in a greater proportion of their assemblages being comprised of imports from extra-regional markets in comparison to sites in the north-west. Without the close proximity of a nearby seaboard via which to access maritime trade, the north-west of the Po valley was forced to rely to a greater extent on goods already circulating in the middle and lower valley, other nearby inland areas, or goods produced or extracted within the upper valley itself.²⁰ In the north-west of the Po valley: assemblages are dominated by goods from a single provenance (Adriatic amphorae and NITS), complemented by the presence of other imported goods either originating from ports located on the coastline at the river mouth (Eastern amphorae), taken from other adjacent inland areas (CITS and GTS) or materials produced in the north-

¹⁷ Carreras and Morais (2012), 429-34. The Dressel 20, however, seems to have achieved minimal penetration along the Ebro valley from the coast (Beltrán Lloris (2000), 477-86).

¹⁸ Beltrán Lloris (1982); (1983); (1987); Castillo (2014). The amphora forms Dressel 2-4, Dressel 28, Tarraconese 1, Tarraconese 2, and Pascal 1 saw widespread diffusion in the Ebro valley (Beltrán Lloris (2008)). In terms of finewares, Terra Sigillata Hispanica was produced in the upper Ebro valley at Tricio and saw widespread distribution both within the Ebro valley and the wider Iberian Peninsula (Beltrán Lloris (1990)).

¹⁹ Fernández Ochoa and Morillo (1994); Morillo et al. (2016).

²⁰ Fernández Ochoa and Morillo (1994); Morillo et al. (2016). The situation becomes more complex away from the Mediterranean. In the major river valleys of the northern provinces, the most common goods were often not produced in the immediate vicinity of the region (e.g. GTS and Iberian oil in the Rhine valley). Military supply and the possibility of state involvement adds an additional layer beyond geography and cost to contend with. See Franconi's ((2014), 212-14) synthesis of amphora material from upper river valleys surrounding the Rhine basin.

west itself (locally quarried stone). A similar situation to the north-western Po valley is seen, for example, in amphora data from the upper Tiber valley. The majority of amphorae dating the Late Republic and Early Imperial Period recovered from the villa at Colle Plinio in the upper Tiber seem to have been produced either locally or regionally, mainly within the middle Tiber.²¹ Imports made up approximately 40% of the total amphorae, almost all of them from the Western Mediterranean.²² The majority of these imports arrived via Portus and travelled upriver to the upper Tiber.

Rivers and mountains played a key role in shaping the distribution of goods across Northern Italy and the Roman world. The network analysis undertaken in Chapter 4 showed that rivers formed corridors of lower cost transport, and, as the material evidence demonstrated, this allowed goods to achieve greater penetration in greater quantities inland. However, the role of overland trade, in particular trans-mountain trade, seems to have had more importance than previously given credit for, especially in areas furthest from the river mouth.

9.2.2 Theory vs. Reality: Complicating Costs

Although the network model used in the analysis generated a number of interesting patterns in terms of the cost and time of transport across the region, its simplicity and the incompleteness of the dataset means that there will inevitably be a level of inaccuracy in the picture it presents. The cost surfaces generated by the model represent an idealised scenario, where a hypothetical one tonne cargo with no previously accumulated transport costs travelled across the region. It assumed that that the maximum price was charged for carriage, that transport would always take the cheapest route, and that all cargo was of the same value. When thinking about transport costs, especially through the lens of network models, it can be tempting to imagine that a hard cut-off point existed, beyond which it was prohibitively expensive to travel, and traders did not cross. Yet this absolutist approach does not reflect the reality of ancient commerce.²³ Merchants traded along rivers, as shown by L. Tettienus Vitalis on the Po and references to the *collegia nautarum* operating on the Lambro, Micino, Po, and Tanaro, while hauliers worked along certain roads, running point-to-point services

²¹ These consisted of locally produced amphorae (e.g. the forms Altotiberine 1-7) or amphorae produced elsewhere within the Tiber valley such as the Spello type (Vidal (1999); (2009)). See also Patterson and Lapadula (1997).

²² Vidal (1999); (2009). The Iberian Peninsula formed the main provenance of these amphorae. The Western Mediterranean provenance of the amphorae recovered from the upper valley reinforces the importance of markets at the river mouth in determining the provenance of supplies within inland regions.

²³ Broekaert (2011); Tchernia (2016), 89-95, 125-28. A single merchant was unlikely to have been responsible for a cargo for the entirety of its journey from source to final sale.

(see Section 3.2.1).²⁴ If demand existed beyond the line at which transport costs were more expensive than those from an alternate origin point, it seems unlikely that merchants would have passed up the opportunity of additional custom. More expensive does not necessarily equal unprofitable and high costs could be ignored if demand was great enough.²⁵

As highlighted above, if transport cost was the dominant factor in determining the inland distribution of goods and cargo, then one would expect to see only goods originating from the Adriatic, Eastern Mediterranean, or within the region appear within assemblages. However, the overlay of the material evidence shows a more complex situation.²⁶ Although transport cost was certainly an important factor in the distribution of material within inland regions, the above analysis suggests that in areas subject to the highest costs, a number of other factors may have come into play that determined the choices made by consumers. The main area where the results of the network model and material analysis do not match is in the west and south-west of the Po valley. Material evidence from this part of the region suggested strong trade links with the Ligurian ports, despite the network model indicating that transport was cheaper from the Adriatic coast. In this section of the valley, where the difference in transport originating from the Adriatic and Ligurian coasts was at its lowest, small changes to the price of transport or extra costs could have significantly altered the viability of one route over another. Transaction costs, such as negotiations and taxes, could significantly increase the price of cargo and transport costs would also have been accrued before goods reached ports in Northern Italy.²⁷ Transport may have been charged less than the maximum, pushing back the point at which transport from an alternative origin became cheaper or vice-versa.²⁸ Goods might also be bought and sold multiple times by the time they reached their point of consumption, further complicating costs.²⁹ Finally, the value of the goods may have been able to absorb the transport costs, most notably in the case of decorative stone.

²⁴ Broekaert (2013); Gabucci and Mennella (2003). See also other *collegia* operating on rivers elsewhere in the Roman Empire (Broekaert (2011); Campbell (2012), 267-70). For hauliers see, Laurence (1999), 134; Perry (2016), 507.

²⁵ Projecting artificial limitations onto data can obscure the true complexity of Roman trade. See Brughmans and Poblome (2017) and Van Oyen (2017) for a discussion of the difficulties of applying formal modelling to ancient datasets.

²⁶ Alternatively, the figures used for transport costs within the model may not accurately reflect prices from Northern Italy in the Roman period.

²⁷ Rodrigue and Notteboom (2020). See Terpstra (2019), Chapter 4 and accompanying bibliography for a discussion of the various transaction costs that could be incurred in Roman trade, alongside Lo Cascio (2018).

²⁸ Contracts may also have included a fixed cost for transport that did not reflect the true cost of carriage. See, for example the papyri discussed in Chapter 4 (see Section 4.3.2), neither of which break down their costs.

²⁹ Rice (2012), 100-102; Tchernia (2016), 261.

Alternatively, demand for specific goods (such as CITS), only available from certain provenances, may have made the cost irrelevant. With this in mind, it is possible that transport from the Ligurian coast was more cost-efficient for a wider range of sites in the west and south-west than the network model suggests.³⁰

The practicalities of transport may also have played a role in the distribution of material. Sites in the west and south-west occupied positions at the end of supply chains originating from the Adriatic coast, located at the furthest distance from these port sites and close to the cut-off points of the navigable river network.³¹ Given the large market at sites closer to the Adriatic ports, hauliers and suppliers may have been unable to meet the demand for goods in the west and south-west of the region, forcing consumers to examine alternative markets despite the higher transport costs. In the case of amphorae at sites in the west and south-west, these were Western Mediterranean markets, but a similar situation is seen to a lesser extent in the north-west of the Po valley. In this instance, sites looked to the Eastern Mediterranean to make up for a shortfall in Adriatic amphorae. Rather than reflecting a lack of transport capacity, the increasing presence of Eastern amphorae further inland, absent in significant quantities in the middle and lower Po valley, may suggest Adriatic producers struggled to meet the demand from sites in the Po's upper reaches.

The above section highlights some of the complexities behind ancient trade and transport which are not present within the network model. Models form important heuristic devices but are, out of necessity, a simplification of real-world conditions. The factors outlined above demonstrates the importance of combining and contrasting models with ancient material evidence.

9.2.3 Amphora, Finewares, and Stone: Contrasting Patterns

Although the discussion above has demonstrated the key role that geography and transport costs played in the distribution of goods, other factors also influenced their circulation. Within this study, the Adriatic, Central and Tyrrhenian Italy, the Eastern Mediterranean, Gaul, the Iberian Peninsula, and North Africa formed the main extra-regional provenances of amphorae, finewares, and decorative stone. Several areas contributed multiple types of material, yet the main provenances were not uniform across the artefact types. A zone of production

³⁰ It is also possible that 159 kg wheat, the near uniform difference in transport cost between the Adriatic and Ligurian ports for sites in the west and south-west of the valley, may simply be the margin of error present within the network model.

³¹ The smaller size of the watercraft operating in the upper reaches of these rivers (and their reduced cargo capacity) may have further compounded their ability to meet demand.

that played a key role in supplying one type of material might be completely absent from the supply of another. For example, Eastern Mediterranean amphorae formed the second largest body of imported vessels in Northern Italy during the first-second centuries AD. Eastern amphorae, arriving at Adriatic ports, had good inland penetration and formed a valuable supplement to Adriatic wine. In contrast, Eastern Sigillata is barely attested and is mainly confined to port sites and those in the coastal hinterland. Eastern Sigillata seems to have been unable to compete with NITS, the predominant fineware in the eastern Po valley and coastal plain.³²

There is a similar disparity between GTS and Gallic amphorae. Gaul was one of the main provenances for terra sigillata during the first-second centuries AD, which was mostly found at sites in the north-west and south-west of the Po valley. However, Gallic amphorae made up a relatively minor percentage of vessels recovered during this period, and were only present in significant quantities in the south-western valley. At the sites of Milan, Como, and Cividate Camuno in the north-west of the valley, Gallic amphorae were entirely absent, despite the comparatively high quantities of GTS within their assemblages. When it comes to Gallic imports, it seems probable that amphorae and finewares travelled by different routes. Gallic amphorae probably entered the region via the Ligurian Apennines, while the distribution of sites with GTS suggests an Alpine route (at least in the north-west). The appearance of GTS in greater quantities than Gallic amphorae may be due to the different ways in which they were consumed. GTS vessels were non-essential items that would be purchased intermittently, whereas wine, in this case carried in Gallic amphorae, represented a more frequently purchased consumable. The profit margins on wine were likely to have been narrow, making it less able to absorb the cost of a trans-Alpine journey than finewares.³³ This situation was further compounded by the low number of amphorae able to fit on a wagon in comparison to the quantities of fineware.³⁴ Ultimately, a variety of factors influenced the provenance of goods within inland regions and some zones of production were better suited to provide certain material types over others.

Wider trends in demand seem to have influenced the distribution of material within Northern Italy, with choice playing a key role. This is readily apparent in the case of CITS, which continued to appear in large quantities even after the

³² This is also reflective of a wider failure of Eastern sigillata to penetrate Western Mediterranean markets, particularly inland regions (Bes (2015); Lund (2003); Papaioannou (2011)).

³³ Tchernia ((2016), 81-82) highlights that trans-Apennine transport costs likely prevented Pliny the Younger from moving a surplus of wine from his estate in Northern Italy to markets in Central Italy which were experiencing a shortfall in supply (Pliny the Younger, *Epistles* 4.6).

³⁴ Picon (2002) estimates that approximately 1500 fineware vessels could be transported on the average wagon, in comparison to 12 amphorae.

establishment and success of workshops in the North. Despite travelling further than locally produced NITS (and crossing a mountain range), the desirability of sigillata from Arezzo, Pisa, and other production centres in Central Italy ensured their continued presence in Northern Italy.³⁵ The extent of demand for Arretine and other Central Italic sigillata allowed Bologna and Modena, despite being located in the Po valley, to be dominated by CITS rather than NITS. These two sites, located at the base of trans-Apennine passes that led to CITS production centres to the south, may have formed important distribution centres for CITS elsewhere in the eastern Po-Veneto plain.³⁶ For amphora cargoes, the spread and overwhelming quantities of some vessel types, particularly the Dressel 6A and 6B which saw the majority of their distribution within Northern Italy (see Section 6.5.1), also attests to the force of directed trade, the specialisation of production, and the strength of connections between Northern Italy and its adjacent regions.³⁷

The ways in which decorative stone was consumed led to it being sourced and distributed in very different ways to the aforementioned ceramic goods. Fine stone and marble was typically put to use as part of broader decorative schemes and some colours (such as yellow *giallo antico*) were only available from single sources, forcing consumers to rely on a select few quarries. The provenance of polychrome decorative stone was remarkably consistent across the study area, and it was only in the north-west of the Po valley, in the areas furthest from either coast, that communities were forced to rely on locally quarried materials in place of imports. There was more leeway for sourcing white marbles, resulting in the split seen between Proconnesian and white Luna marble between the east and west of the region.³⁸

9.2.4 Chronological Variations

The majority of the discussion has so far related to inland trade during the first-second centuries AD, roughly encompassing the Early and High Imperial period. This is largely a reflection of the lower quality or absence of data from the preceding and following periods. Despite this, some important observations can still be made regarding how patterns in trade evolved in Northern Italy over the Roman era.

The material analysis demonstrated that the main provenances of ceramic

³⁵ The desirability of CITS is seen through the imitation of decoration associated with Arretine vessels on some NITS and the stamping of some Northern Italic vessels with *ARRET* to demonstrate comparable quality or pass-off their origin as Arretine. See Gabucci and Quiri (2008), 51-52; Mantovani (2013), 236-41; Mazzeo Saracino (2000), 34-38.

³⁶ Kenrick (1993); Van Oyen (2015), 285-86; Zabehlicky-Scheffenecker (2003), 117.

³⁷ Auriemma (1997); Carre (2007a); (2007b); Rousse (2007); Van Limbergen (2018).

³⁸ Russell (2018a), 139-40.

material within Northern Italy changed chronologically, reflecting the rise and fall of different areas of production across the Roman world.³⁹ In the Late Republic, there seems to have been a limited choice in the variety of extra-regional imports. The overwhelming majority of amphorae of this date recovered from the region originated from the Adriatic, with minimal quantities of Tyrrhenian, Iberian, and North African vessels also present. Although transport costs in the Late Republic may have been more expensive than the totals suggested by the network model (given that most transport infrastructure would not be completed until the Imperial period), the lack of choice forced the bulk of consumers to rely on a limited range of products, regardless of their location within the region.⁴⁰

Moving into the Imperial period, as new zones of production, such as those in the Iberian Peninsula and Southern Gaul, were established and Mediterranean connectivity improved, a greater range of imported goods became available in Northern Italy through strong extra-provincial trade links.⁴¹ While the central and eastern valley continued to rely on goods produced in the Adriatic or the eastern Po-Veneto plain, sites on the north-west, west, and south-west of the region tapped into new zones of production. The cost of transport to these locations, on the peripheries of the Po valley, was similar from both the Adriatic and Ligurian coasts (as well as Gaul and Germany in the case of sites in the north-west). As a result, consumers made the most of the choice of products on offer, diversifying their assemblages.

By the Late Antique period, the choice presented to consumers reduced once more as the visible market became dominated by a small number of production zones. For amphorae, Eastern, Iberian, and North African vessels made up the majority of imports, while for finewares, ARS from North Africa dominated assemblages. The shift in provenance for material assemblages in Late Antiquity reflects wider economic trends, as new zones of production came to prominence while others declined.⁴²

The divide between the east and the west of the region was consistent across the Roman period. For the amphora data, across all three chronological periods, sites in the west of the Po valley had a significantly higher portion of Western Mediterranean vessels in their assemblages than others in the region. For the

³⁹ The publications of most decorative stone assemblages excluded a chronological element, making it difficult to track changes in trade (see Section 5.2.3).

⁴⁰ The network model represents the transport network at its full extent seen during the Imperial period.

⁴¹ Wilson (2012), 288; Wilson et al. (2012).

⁴² Auriemma et al. (2012); (2015); Lewit (2015); Tchernia (2016), 310-16. Of course, as to whether the archaeological evidence truly reflects the decline of production in some regions or a shift to perishable containers which do not survive is a matter of debate (McCormick et al. (2012), 74-77).

fineware data, assemblages from sites in the west of the region were also routinely distinct from their eastern counterparts. The regular division between the east and west of the region across the chronological periods serves to reinforce the important role geography played in the distribution of goods inland. Although the infrastructure projects of the Augustan period and first century AD would serve to decrease the point at which geography impacted on cost, this only served to reinforce existing patterns in distribution evident from the Republican period.⁴³

9.3 The Question of Exports

The majority of this thesis has concentrated on the distribution of imported goods, yet these represent only one direction of trade. The absence of a return cargo for traders operating in the upper Po valley would have further increased transport costs and seems an unlikely scenario.⁴⁴ Northern Italy was said to have exported several high-quality products according to the literary sources, notably wool, linen, and associated clothing, timber, and pork from its swine herds.⁴⁵ These are all organic goods, most of which either do not survive in the archaeological record or would be difficult to provenance. Consequently, a large part of the region's economic picture is missing.⁴⁶

In terms of foodstuffs, in the past there has been little evidence to suggest that the Po valley served as a major producer of food for extra-regional consumption in the same way as other major river valleys, such as the Guadalquivir in the Iberian Peninsula, or the Nile in Egypt. However, looking at Northern Italy's

⁴³ The expansion of infrastructure across Northern Italy during this period represents a key example of indirect state involvement in economic development. It is uncertain who funded the massive expansion in port infrastructure across Northern Italy between the late first century BC and first century AD, but these large, civic projects likely had a level of state involvement. Emperors were responsible for the creation of the para-littoral canals, and the major trans-Alpine extension of the via Postumia between Piacenza and Genoa (the via Julia Augusta) in 13 BC, and the trans-Alpine via Claudia Augusta in AD 46-47, were also constructed by the state (see Section 3.2.1). Without these infrastructure projects, it seems unlikely that the intensity of trade seen between the south-west of the Po valley and the Ligurian ports during the first-second centuries AD could have occurred, nor could the Po river network have facilitated the mass transport of goods and materials far inland. For comments on state construction of infrastructure and economic development, see Wilson (2009a): 81; Wilson and Bowman (2018b), 5-8.

⁴⁴ On the importance of return cargoes, see Bonifay (2003); Rice (2016), 173-74; Wilson et al. (2012), 368-70.

⁴⁵ Polybius, 2.15; Strabo, 5.1.12; Varro, *de re rustica* 2.4.11.

⁴⁶ Evidence for some of these activities survives in some circumstances. Networks of textile producers (*collegia centonaria*) have been reconstructed through epigraphy (Liu (2009); Roncaglia (2018), 89-100), while archaeological evidence exists for sheep rearing and sheering, for example the villa at Roncade-Ca' Tron close to Altinum (Busana et al. (2012)) and the villa at Dal Molin (Gamba et al. (2012)). Fentress' (1990) survey of Diana Veteranorum and its associated textile production may provide a model for future studies.

villa landscape, a wide range of food is shown to have been produced, with sites containing multiple wine or oil presses attested across the region, alongside examples of cereal cultivation, drying, and storage.⁴⁷ This raises the question of whether the food produced at these sites was being consumed within the region or exported extra-regionally. The largest and most complex productive villa sites so far discovered in Northern Italy have been in the east, corresponding to the area of ancient *Regio X*. It has been hypothesised that this was due to the demand from the army on the Danubian *Limes*, the east of the region being geographically closest to the frontier.⁴⁸ The initial part of the journey to the frontier would have been overland, crossing the Dinaric Alps before reaching the headwaters of the Sava and other tributaries of the Danube.⁴⁹ From the *Limes*, amber, hides, metal goods, ore, and slaves were transported to Northern Italy as return cargoes for this trade.⁵⁰

When it comes to food production, tracking possible exports is hampered by the failure of a distinctive ‘Northern Italic’ amphora form to develop. The only amphorae known to have seen sizeable production within the region are the Dressel 6A/6B (to an extent) and the Flat-Bottomed Italic ‘Forlimpopoli’ forms.⁵¹ The majority of Dressel 6As were produced further south along the Adriatic coast at Picenum and the Dressel 6B saw only a limited period of production in Northern Italy, before being entirely replaced by those coming from Istria (see Section 6.5.1). Flat-Bottomed Italic amphorae were produced in the south-east of the region, close to Forlì, from the early second century AD to late-second, early third century AD as production of the Dressel 6A/6B began to decline. While they appeared in minimal quantities inland, Flat-Bottomed Italic amphorae seem to have been primarily traded along the Adriatic coast and within the Eastern Mediterranean during their brief period of production.⁵² Nonetheless, it is unclear the extent to which the majority of the region, further inland from Forlì, played in providing the contents of these amphorae.⁵³

Although exports of foodstuffs have proved hard to trace archaeologically,

⁴⁷ Forin (2017), 132-70 provides an exhaustive list of villas with production facilities within Northern Italy. The presence of multiple presses at many sites suggests the production of a surplus. A similar situation has been identified for the Ebro valley, from which few regionally produced amphora have been recovered yet contained a well-developed villa landscape (Beltrán Lloris (1982); (1983)).

⁴⁸ Busana and Forin (2020), 25-26; Scagliarini Corlàita (1989), 33.

⁴⁹ Gabucci and Mennella (2003); Gregoratti (2015).

⁵⁰ Buora (2001); Mócsy (1974), 130; Roncaglia (2018), 106-11.

⁵¹ Busana et al. (2009), 35-41; Cipriano and Mazzocchin (2004), 108-10; (2018), 261-62; (2019), 242-43.

⁵² Panella (2002), 195-96.

⁵³ It is possible that wine produced further inland was transported to Forlì in larger, perishable containers for re-packaging prior to export.

there is firm evidence for the export of NITS from Northern Italy. The main distribution of NITS was along Italy's Adriatic coast and the Danubian frontier, where it is found in significant quantities. It is almost entirely absent from the Western Mediterranean and northern provinces.⁵⁴ Other ceramics produced in Northern Italy such as lamps have also been found along the Danubian frontier.⁵⁵ It is unknown if Northern Italic ceramics piggy-backed on other goods exported from the region but the frontier and Danubian provinces offered a ready market in close proximity.⁵⁶ To return to the merchant L. Tettienus Vitalis who traded up and down the Po, his grave monument also proclaimed that he traded on the Sava. The Danube's longest tributary, the Sava formed an important transport corridor for goods in the Upper Adriatic area, especially given its headwater's proximity to Aquileia.⁵⁷ It is unknown what Vitalis was transporting but his business affirms the west-east axis of trade from Northern Italy.

In comparison to amphorae and finewares, there is very little evidence for stone exports from Northern Italy. Few stones were of sufficient fineness to warrant decorative use and those that were, such as Musso and Verona Rosso marble, were mainly traded within the immediate vicinity of their quarries. More durable lithotypes prized for their hard-wearing properties, such as Euganean trachyte, saw wider distribution but this remained at a regional level.⁵⁸ This is unsurprising, given that the cost involved in extracting and transporting stone meant that inland quarry zones were immediately disadvantaged when compared to those on the coast.

9.4 A Disconnected and Isolated Region?

Northern Italy's unique situation and geography has allowed it to function as a sandbox for exploring wider questions relating to inland trade in the Roman period. The material analysis demonstrated that despite their distance from the

⁵⁴ Brusić (1999); Košćević and Makjanić (1995); Mercado (1972); Mertens (1972); Schindler-Kaudelka (1980).

⁵⁵ Duch (2017), 195-97; Egri (2007); Schindler and Zabehlicky Scheffenecker (1977); Tassaux (2004).

⁵⁶ This is a question that concerns fineware ceramics more broadly. Although shipwreck evidence confirms that finewares (both terra sigillata and ARS) piggybacked on the maritime trade of other goods, the mechanics of how it travelled inland are more difficult to track (Dannell and Mees (2013), 175-76; Lewit (2015), 115-18).

⁵⁷ Arioli (2019), 144. For trans-Alpine trade from the Adriatic into the Danubian Limes more generally, see Ehmig (2010), 155-156.

⁵⁸ Previato and Mareso (2015); Previato and Zara (2018). An example of a column capital carved from Aurisina limestone was discovered at the quarries of Proconnesus. While it could be argued this is reflective of some limited trade in Aurisina outside of the Adriatic, it seems more likely the capital served as a model for a commission of Proconnesian capitals (Russell (2013), 208-09).

coast, inland sites in Northern Italy were connected to wider markets in the Eastern and Western Mediterranean. The quantities and distribution of material examined make prior claims of Northern Italy's geographic and economic isolation untenable, and the results of the combined network and material analyses defies several long-held assumptions on the nature and limitations of inland trade.

The analysis undertaken here further challenges the long-held assumption (one that has been increasingly confronted over recent years), that overland trade was prohibitively expensive except in very specific circumstances.⁵⁹ The perceived limitations placed on transporting goods in significant quantities or heavy cargoes to areas not on the coast or a navigable river have been stated time and time again.⁶⁰ The only supposed exceptions to this rule were luxury items, the demand for which (and the high initial purchasing costs) made transport costs irrelevant.⁶¹ However, as demonstrated by the material analysis, staple goods were travelling inland via difficult overland routes in significant quantities, pointing to sustained trade rather than one-off purchases. The ability of overland transport to make significant contributions has been routinely underestimated and the results of the material analysis serve to reinforce the tandem roles of fluvial and overland transport in supplying inland regions.

The study revealed serious flaws in prior network analyses undertaken on Roman transport and connectivity in Northern Italy. While the network analysis undertaken within this thesis is not without its own limitations, it is clear previous studies have underestimated Northern Italy's connectivity, both internally and to adjacent regions. The network model in this thesis is a route network model, following a similar design to ORBIS although at a much greater resolution. The density of Northern Italy's water and terrestrial transport network mapped during the analysis resulted in much lower values for the cost and time of moving across the region, something over-estimated by both ORBIS and Carreras and de Soto's modelling (see Chapter 4). Although the issue of model resolution has been discussed elsewhere in the thesis, more problematic elements originate from Carreras and de Soto's examination of degree centrality within their model.⁶² Degree centrality (the number of links incident upon a node) forms a simple method of identifying highly connected nodes within a network.⁶³ However, its application in Carreras and de Soto's model led to unexpected spikes and dips

⁵⁹ Gabucci (2017); Laurence (2005), 138; Lewit (2015); Wilson (2012); 228.

⁶⁰ Bonifay (2004), 451-2; Horden and Purcell (2000), Chapters 4 and 5; Tchernia (2016), 90-93; Temin (2001), 179-81.

⁶¹ Harris (2007), 535.

⁶² Carreras and De Soto (2013); De Soto (2019); De Soto and Carreras (2014).

⁶³ De Soto (2019), 278-80. While not as complex as metrics such as Betweenness and Closeness Centrality, nodes ranked highly by Degree Centrality are often ranked highly by other metrics (Golbeck (2013), 23).

in connectivity not reflected in the distribution of ancient material (see Chapter 4).⁶⁴ This underscores the importance of using network models in conjunction with other forms of evidence, against which their results can be compared and contrasted, and the dangers of the uncritical acceptance of their conclusions.

The statistical analysis demonstrated the importance of moving beyond qualitative approaches to material data. While much of the material discussed in this thesis had been quantified and studied at site level by material specialists, it had rarely been applied to wider regional investigations. Where possible trends in material across Northern Italy have been previously highlighted, these have not been examined quantitatively or tested statistically.⁶⁵ The statistical analysis has proved a more rigorous approach than simply comparing datasets by eye, picking up trends that might not otherwise have been noticed.

The material evidence from Northern Italy forms a crucial counterpoint to the network model from the first half of the thesis, and its analysis challenges the concept that inland areas were restricted in the types of material they could access. Past thinking on inland trade has theorised a steep drop off in imported goods as distance from the coast increased.⁶⁶ Although the material analyses do show a clear evolution in the provenance of imports as distance inland from the Adriatic coast increased, the diversity of assemblages increased rather than declined, in the case of ceramic goods.⁶⁷ Although port sites had access to the widest variety of goods and materials through their maritime connections, the analysis demonstrates that this diversity did not extend to sites in their immediate vicinity when it came to ceramic products. While the ports themselves regularly recorded some of the highest diversity scores in the region, assemblage diversity for sites in the coastal plain and eastern Po valley was low. Instead, sites at the greatest cost distance from a seaport often possessed the greatest diversity in the type and provenance of their material, often comparable to that of port sites. These sites drew from both Eastern and Western Mediterranean markets to supply their needs, with Eastern, Gallic, Iberian, and Tyrrhenian goods appearing in quantities not seen elsewhere within the Northern Italy. Unfortunately, the quality of the material data prevents an accurate reading on how the overall quantities of material changed from site-to-site. It may be that the sites furthest inland, while exhibiting a high level of diversity in their imports, received them in overall lower

⁶⁴ See, for example, the high levels of connectivity around Piacenza and the mouth of the Po, while the middle Po and upper valley returned much lower values.

⁶⁵ For example, Filippi (1995); Gabucci (2017); Galli 1996; Melli (2004).

⁶⁶ Bonifay (2018); Fulford (2009), 253; Lavan (2015b), 3; Vaccaro and MacKinnon (2014).

⁶⁷ As highlighted above, the situation was more complex for stone assemblages. Those in the north-west of the Po valley recorded the highest diversity, while those in the south-west of the valley recorded the lowest diversity.

quantities than those closer to the coast.⁶⁸ Short-distance trade in perishable containers such as skins may have made a more important contribution in these areas rather than long-distance amphora-borne goods.⁶⁹ Unfortunately, the uneven nature of excavation and the archaeological record makes it unlikely there will ever be a way to satisfactorily measure the quantities of goods circulating within inland regions.

The high diversity of ceramic vessel forms and provenances at sites in the upper river valley and their distinct assemblage composition presents interesting questions regarding the cost and logistics of supplying inland regions. It is worth highlighting that goods which had either been produced within Northern Italy or in close proximity to it, those with minimal transport costs prior to entry into the region, made up the majority of ceramic assemblages. However, it is clear that, at some point, these goods either lost their comparative advantage or struggled to fulfil the demand of areas at the end of the supply chain.⁷⁰ As a consequence, urban sites in the upper valley increasingly relied on markets at a greater distance from Northern Italy in order to meet their demand. Whether sites at the greatest distance from the river mouth turned to wider markets out of choice or necessity is open to debate, but it is evident that a complex array of factors, of which transport cost was a significant element, governed the provenance of their material. In contrast to the ceramic evidence, the stone and marble analyses serve to largely confirm pre-existing notions on how heavy cargoes moved within inland regions.⁷¹ The high costs associated with moving such goods served to limit their distribution. Although some inland sites exhibited lower diversity, transport costs did not stop sites at the greatest distance from the coast accessing decorative stone from markets in the Eastern Mediterranean and North Africa. Where there was demand, obstacles could be overcome.

The role consumer choice played in the distribution of material in Northern Italy is difficult to answer. The analysis within this thesis was undertaken at a broad level due to the size, scope, and limitations of the datasets. The actual artefacts themselves, their specific finds contexts, and the ways in which they were used once after they had arrived at their point of consumption, were not engaged

⁶⁸ Turin forms a case in point. There are known to be at least 10,000 (currently unpublished) amphora sherds from the piazza Castello and Giardini Reali excavations in Turin, one of the most westerly sites in the region (Quiri (2009); (2015)). Although this is a large number, to what extent is it exceptional, especially given that they were recovered from one of city's main refuse middens. Might similar, or larger figures be recovered from similar contexts at sites closer to the coast?

⁶⁹ Panella and Tchernia (1994), 159-60; Tchernia (1986), 285-92.

⁷⁰ For discussions on comparative advantage across and within regions, see Heckscher and Ohlin (1991); Martin (2006), 164-66; Scheidel (2012); Temin (2012), 55-60.

⁷¹ See the arguments outlined in Russell 2018.

with. This thesis has primarily used the material datasets in a representative way (i.e. where material is analysed as a substitution for something else, such as identity or cultural practices) to examine broader economic questions, using them as proxies for trade in the Roman period.⁷² Representative studies of material culture have been criticised in recent years, particularly those working along theories of materiality.⁷³ There can be no doubt that a greater level of complexity was present in the material distribution than explored by this thesis, and more nuanced analysis of the artefacts themselves and the ways in which they were consumed could shed additional light on distribution patterns (for example that of CITS). Furthermore, Pitts rejects the dichotomy that ‘distribution patterns must either be explained in terms of local (cultural) choice, or the manifestation of bigger (economic) market systems’.⁷⁴ However, the analyses within this thesis suggest that, in some cases, where there is evidence of choice playing a potential role in the distribution of material, this was, in fact, a by-product of wider economic circumstances. For example, the amphora data from the south-west of the Po valley implies either traders struggled to meet demand at the end of Adriatic supply chains (forcing consumers to choose goods from other producers), or an evening-out of transport costs from the Adriatic and Ligurian ports made a wider array of goods competitive (allowing consumers greater choice). Within this scenario, consumers may have been able to choose individual vessel types based on desirable qualities, but the overall provenances of the material available was subject to wider economic trends. Price and availability seem to have been the main factors dictating the spread of goods within the region.⁷⁵

Knowledge and exchange of information would have been central to the workings of inland markets.⁷⁶ Sites in the upper valley contained high quantities of material not seen in the middle and lower valley, some of which travelled upriver along the Po, and some overland across the Alps and the Apennines. Such large quantities of staple goods did not move speculatively. Traders operating out of the Ligurian ports would have needed an awareness of markets on the other side

⁷² Scheidel (2009); Verboven (2021); Wilson (2009a); (2009b); (2014).

⁷³ Materiality is defined as the ‘cultural nexus between artefact and person’ (Taylor (2009), 299). For criticisms of representative studies of ancient material, see Pitts (2017); Van Oyen and Pitts (2017).

⁷⁴ Pitts (2017), 64. See also Gardner (2007), 91-96.

⁷⁵ This is reflective of Temin’s model of an ‘instrumental’ economy (Temin (2001), 171-72; (2013), 7-9). In this scenario, human actors, driven by array of motivations such as profit, are responsible for material redistribution. See also Poblome and Waelkens (2003); Poblome et al. (2017), 96 for a discussion of correlation between economic rational, market-functioning, and the distribution of Roman material.

⁷⁶ The importance of the ‘information economy’ in trade and exchange has been increasingly noted over the past decade. See Bang (2008), 288; Brughmans (2020); Brughmans and Poblome (2016a); (2016b); (2017); Temin (2013); Van Oyen (2017).

of the Apennines before moving cargoes across the mountains, with the same being true for trans-Alpine trade. The cost of the journey alone would not have been worth the risk of being unable to sell the cargo on the other side, or indeed the lack of a return cargo. Similar concerns would have affected fluvial traders operating between the lower and upper reaches of the Po water network. Networks of market information extended beyond the region itself and areas in its immediate vicinity to the wider Mediterranean. Cargoes of Eastern amphorae or North African finewares travelling up the Po to supply sites in the north-west of the Po valley are unlikely to have arrived at ports in the Northern Adriatic, a so-called ‘maritime dead-end,’ by chance.⁷⁷ Knowing the locations of extra-regional markets and the type and style of goods in demand there was crucial for shippers and traders operating between zones of production and consumption.⁷⁸ Sites in Northern Italy are unlikely to have dealt with the source regions of these goods themselves (the exception being for architectural stone, as the nature of commissioning large public projects meant that buyers would have needed to liaise directly with a quarry).⁷⁹ Merchants and other go-betweens would have instead relayed details between markets and suppliers. Rather than being isolated and disconnected, Northern Italy was integrated into wider Mediterranean networks of supply and information.

9.5 Conclusions

Despite the (sometimes considerable) costs involved, inland regions were not excluded from wider Mediterranean markets in the Roman world. The combination of the network and material analyses carried out in this thesis has allowed a greater depth of understanding of how cost, geography, and a host of other factors affected inland trade and exchange. Rivers were important transport arteries and there is no doubt that they allowed goods to travel further inland in greater quantities, and for a lower cost than would otherwise have been achievable via solely overland transport. Prior concerns over the navigability of the Po river network and the role it played in trade during the Roman period are untenable in the face of the evidence synthesised. There was, however, a limit to the river network’s effectiveness. Overland transport could, and did, play a crucial part in supplying inland regions, not just in luxury items but staple goods. Although the image presented by the combined analyses demonstrates how transport costs played an important role in influencing the distribution of material within inland

⁷⁷ Harris (2011b), 196-7; Scheidel (2014), 21.

⁷⁸ Bes (2015), 82.

⁷⁹ Russell (2011), 137-38; (2013), 211-14.

regions, a singular focus on costs risks obscuring the fact that fluvial and overland transport were not competing systems. As the material analysis demonstrated, Northern Italy relied on both forms of transport to supply inland sites.

Network modelling and statistical analysis played a key role in producing the results outlined in this thesis. Formal modelling and simulation are becoming increasingly important tools applied to the study of the Roman economy, ones that have the potential to clear up ambiguities and test the validity of past hypotheses.⁸⁰ Using data that have previously only been studied in isolation or qualitatively, the network models and statistical analysis in this thesis were able to conclusively challenge several orthodoxies regarding inland trade in Northern Italy. Clear zones of consumption could be seen across the region, but there was not a drop-off in imports as distance from the coast increased. Most notably, within Northern Italy, sites furthest inland often possessed the greatest diversity in vessel forms, lithotypes, and provenance, an inversion of the expected pattern of coastal areas using their location and connectivity to access a wider variety of goods.

The methodology brought to bear on the material datasets analysed within this thesis proved highly successful at answering the questions it was designed to address, opening up further avenues of research. The methodology has the potential to be applied at a similar scale to other inland regions, offering a valuable comparison to the results from Northern Italy. How might the inland distribution of goods differ in a region lacking Northern Italy's unique geography? The methodology can also be applied to other types of material data. While this thesis utilised widely published amphora and fineware data (alongside more limited stone and marble assemblages), how far might trends in distribution extend to other material, such as glass and metal? The material datasets composed for this thesis form a powerful tool, one that has the potential to form the basis of other types of analysis. Moving beyond networks towards simulation, such as that performed by Project MERCURY, these data have the potential to be applied to more complex models and hypotheses relating to inland trade.⁸¹ Additionally, as more material is published and becomes available, attempting an analysis with a finer chronological resolution may offer additional insight into inland distribution patterns. Finally, while the thesis deliberately chose to focus on broader trends within the data, a closer analysis of the material itself may bring forth greater nuance as to why certain provenances, vessels, and lithotypes were favoured by consumers.

⁸⁰ Brughmans (2022); Brughmans and Wilson (2022).

⁸¹ Brughmans (2020). See Brughmans (2022) for a discussion on why simulation will form the next major avenue of research in the study of the Roman economy.

The results presented in this thesis will not be a perfect reflection of transport and trading practices in ancient Northern Italy. Patterns can, and will, change as new and greater quantities of data become available. However, the thesis has demonstrated the power of large, quantified datasets in exploring questions related to trade and distribution, alongside the importance of using archaeological material evidence in conjunction with computational modelling. The picture that has emerged of inland trade in Northern Italy is far more complex than previous studies have accounted for, and the image of an isolated and disconnected region, with minimal choice and access to imports, is no longer viable.

Bibliography

- Abdelhamid, S. (2013). Against the throw away mentality: The reuse of amphoras in ancient maritime transport. In Hahn, H. and Weiss, H., editors, *Mobility, Meaning and the Transformations of Things*, pages 91–106. Oxford.
- Acari, L. (1996). Un deposito di anfore in via Massarotti a Cremona. In Facchini, G., Passi Pitcher, L., and Volonte, M., editors, *Cremona e Bedriacum in età romana I. Vent'anni di tesi universitarie*, pages 185–203. Milan.
- Adams, C. (2001). Who bore the burden? The organization of stone transport in Roman Egypt. In Mattingly, D. and Salmon, J., editors, *Economies Beyond Agriculture in the Classical World*, pages 171–193. London.
- Adams, C. (2007). *Land transport in Roman Egypt a study of economics and administration in a Roman province*. Oxford.
- Adams, C. (2012). Transport. In Scheidel, W., editor, *The Cambridge Companion to the Roman Economy*, pages 218–240. Cambridge.
- Adams, C. (2018). Nile River Transport under the Romans. In Wilson, A. I. and Bowman, A., editors, *Trade, Commerce, and the State in the Roman World*, Oxford Studies on the Roman Economy, pages 175–208. Oxford.
- Agnoletti, M. (2013). *Italian historical rural landscapes cultural values for the environment and rural development*. Dordrecht and New York.
- Agostoni, A., Barello, F., Borghi, A., and Compagnoni, R. (2017). The White Marble of the Arch of Augustus (Susa, North-Western Italy): Mineralogical and Petrographic Analysis for the Definition of its Origin: The white marble of the Arch of Augustus (Susa, Italy). *Archaeometry*, 59(3):395–416.
- Airoldi, F., Cipriano, S., and Montevecchi, G. (2018). Suppelletile da mensa. In Guarnieri, C. and Montevecchi, G., editors, *Il Genio delle Acque. Scavi nelle piazze di Ravenna*, pages 107–20. Ravenna.
- Aldini, T. (1978). Anfore Foropoliensi. *Archeologia Classica*, 30:236–45.
- Aldini, T. (1989). Nuovi dati sulle anfore foropoliensi. *Studi Romagnoli*, 40:383–418.
- Aldini, T. (1995). Elementi per una più corretta classificazione delle anfore foropoliensi. *Atti e Memorie della Deputazione di Storia Patria per le province di Romagna*, 46:11–18.

- Aldini, T. (1999). Anfore foropopiliensi in Italia. *Forlimpopoli. Documenti e studi*, 10:23–56.
- Aldini, T. (2000). Archeologia Bertinorense Forlimpopoli. *Documenti e studi*, 11:23–66.
- Allini, A., Asta, A., Medas, S., and Miari, M. (2014). Due piroghe rinvenute nel fi ume Po presso Monticelli d’Ongina (PC) e Spinadesco (CR). In Asta, A., Caniato, G., D., G., and Medas, S., editors, *Archeologia Storia Etnologia Navale. Atti del II convegno nazionale Cesenatico – Museo della Marineria (13-14 aprile 2012)*, pages 117–24. Padua.
- Allison, P. (2004). *Pompeian Households: An Analysis of Material Culture*. Los Angeles.
- Amadori, C. (1996). La terra sigillata proveniente dai “vecchi scavi” di Cremona. In Facchini, G. M. and Passi Pitcher, L., editors, *Cremona e Bedriacum in età romana. I. Vent’anni di tesi universitarie*, pages 99–124. Milan.
- Andreu Pintado, J., Royo Plumed, H., Lapuente, P., and Brilli, M. (2015). Imported marbles found in three Roman cities of the territory of “Cinco Villas” (Zaragoza), north of Hispania Citerior. In Pensabene, P. and Gasparini, E., editors, *ASMOSIA X. Proceedings of the Tenth International Conference of ASMOSIA Association for the Study of Marble Other Stones in Antiquity Rome, 21-26 May 2012*, pages 13–22. Rome.
- Andris, C. and O’Sullivan, D. (2021). Spatial Network Analysis. In Fischer, M. and Nijkamp, P., editors, *Handbook of Regional Science*, pages 1727–1750. Berlin, Heidelberg.
- Angelelli, C. (2014). Materiali lapidei da rivestimento dalle campagne di scavo 2009-2011. In Rossi, F., editor, *Un luogo per gli dei: l’area del Capitolium a Brescia*, pages 491–97. Florence.
- Angelini, R. (2018). *Romanità di Cattolica. Gli scavi 2004 nell’area Pritelli*. Cattolica.
- Annibaletto, M., Cipriano, S., Riccobono, D., Sandrini, G., Veronese, F., and Vigoni, A. (2007). Catalogo. In Pettenò, E., editor, *Vasa Rubra. Marchi di fabbrica sulla terra sigillata da Iulia Concordia*, pages 69–292. Padua.
- Antico Gallina, M. (2011). Strutture ad anfore: un sistema di bonifica dei suoli. Qualche parallelo dalle Provinciae Hispanicae. *Archivo Español de Arqueología*, 84:179–205.
- Antico Gallina, M. (2014). Dalla Topografia al Diritto. Sistemi ad anfore e mutamenti verticali del suolo. *Atlante tematico di topografia antica*, 24:233–46.
- Antonelli, F. and Lazzarini, L. (2016). An updated petrographic and isotopic reference database for white marbles used in antiquity. *Rendiconti Lincei Scienze Fisiche e Naturali*, 26:399–413.

- Arioli, L. (2019). Roman pottery and trade networks. some notes on Italian sigillata in the lower Danube and in the north-western Black Sea. In Schirripa, P., editor, *Greci e Romani sulle sponde del Mar Nero*, pages 129–68. Milan.
- Arnaud, P. (2007). Diocletian’s Prices Edict: the prices of seaborne transport and the average duration of maritime travel. *Journal of Roman Archaeology*, 20:321–335.
- Arnoldus, A., Bowes, K., Grey, C., Ghisleni, M., and Rattighieri, E. (2021a). Podere Terrato. In Bowes, K., editor, *The Roman Peasant Project 2009-2014: Excavating the Roman Rural Poor*, pages 237–64. Philadelphia.
- Arnoldus, A., Bowes, K., Grey, C., Ghisleni, M., and Rattighieri, E. (2021b). Poggio dell’Amore. In Bowes, K., editor, *The Roman Peasant Project 2009-2014: Excavating the Roman Rural Poor*. Philadelphia.
- Artru, F. (2016). *Sur les routes romaines des Alpes Cottiennes, entre le Mont-Cenis et col de Larche*. Besançon.
- Attanasio, D., Brillì, M., and Bruno, M. (2008). The properties and identification of marble from Proconnesos (Marmara Island, Turkey): a new database including isotopic, epr and petrographic data. *Archaeometry*, 50(5):747–774.
- Attanasio, D., Yavuz, A., Bruno, M., J.J., H., Tykot, R., and van den Hoek, A. (2012). On the Ephesian Origin of Greco Scritto Marble. In Garcia-M, A., Mercadal, P., and Rodà de Llanza, L., editors, *Interdisciplinary Studies on Ancient Stone. Proceedings of the IX Association for the Study of Marble and Other Stones in Antiquity (ASMOSIA) Conference (Tarragona 2009)*, pages 245–54. Tarragona.
- Auriemma, R. (1997). Le anfore africane del relitto di Grado. Contributo allo studio delle prime produzioni tunisine e del commercio di salse e di conserve di pesce. *Archeologia Subacquea. Studi, ricerche e documenti*, 2:129–55.
- Auriemma, R. (2000). Le anfore del relitto di Grado e il loro contenuto. *Mélanges de l’école française de Rome*, 112:27–51.
- Auriemma, R. and Degrassi, V. (2017). Anfore del Mediterraneo Orientale. In Maggi, P., Maselli Scotti, F., Pesavento Mattioli, S., and Zulini, E., editors, *Materiali per Aquileia: lo scavo di Canale Anfora (2004-2005)*, pages 329–72. Trieste.
- Auriemma, R., Degrassi, V., and Quiri, E. (2012). Produzione e circolazione di anfore in Adriatico tra III e IV secolo: dati da contesti emblematici. In Fioriello, S., editor, *Ceramica Romana nella Puglia Adriatica. Indagini archeologiche a Egnazia. Dallo scavo alla valorizzazione*, pages 255–98. Bari.
- Auriemma, R., Degrassi, V., and Quiri, E. (2015). Eastern amphora imports in the Adriatic Sea: evidence from terrestrial and underwater contexts of the Roman Imperial age. In Demesticha, S., editor, *Per Terram, Per Mare: Seaborne*

- Trade and the Distribution of Roman Amphorae in the Mediterranean*, pages 139–60. Uppsala.
- Auriemma, R. and Pesavento Mattioli, S. (2009). I titoli picti delle anfore di Grado. In Pesavento Mattioli, S. and Carre, M., editors, *Olio e pesce in epoca romana. Produzione e commercio nelle regioni dell'alto Adriatico*, pages 275–80. Rome.
- Auriemma, R. and Quiri, E. (2004). Importazioni di anfore orientali nell'Adriatico tra primo e medio impero. In Eiring, J. and Lund, J., editors, *Transport Amphorae and Trade in the Eastern Mediterranean. Acts of the International Colloquium at the Danish Institute at Athens, September 26-29, 2002*, pages 43–55. Athens.
- Bacchetta, A. and Venturino Gambari, M. (2008). *Raccolta archeologica di Augusto Scovazzi*. Genoa.
- Bacchetta, A. and Venturino Gambari, M. (2017). *La città ritrovata: Il Foro di Aquae Statiellae e il suo quartiere*. Acqui Terme.
- Baldoni, D. (1986). Materiali di scavo: gli strati della fase repubblicana. In Ortalli, J., Baldoni, D., and Curina, R., editors, *Il teatro romano di Bologna*, pages 121–51. Bologna.
- Balista, C. and Bianchin Citton, E. (1987). Montagnana - Borgo S. Zeno, indagine geoarcheologica: nuovi elementi di studio per l'abitato protostorico e l'antico tracciato del fiume Adige. *Quaderni di Archeologia del Veneto*, 3:11–19.
- Balista, C., Bianchin Citton, E., and Tagliaferro, C. (2010). Il Paleoadige tra Montagnana ed Este: nuovi dati per una lettura geoarcheologica delle scogliere di età romana. *Quaderni di Archeologia del Veneto*, 26:138–50.
- Balista, C. and Ruta Serafini, A. (1993). Saggio stratigrafico presso il muro romano di Largo Europa a Padova. Nota preliminare. *Quaderni di Archeologia del Veneto*, 9:95–111.
- Bang, P. (2008). *The Roman Bazaar: A Comparative Study of Trade and Markets in a Tributary Empire*. Cambridge.
- Bang, P. (2012). A Forum on Trade: Bazaars, Empires, and Roman Trade. In Scheidel, W., editor, *The Cambridge Companion to the Roman Economy*, pages 296–303. Cambridge.
- Bannon, C. (2020). *A Casebook on Roman Water Law*. Ann Arbour.
- Bargnesi, R. (2004). Inland navigation in ancient Northern Italy: The port of Ticinum. In Pasquinucci, M. and Weski, T., editors, *Close Encounters: Sea and Riverborne Trade, Ports and Hinterlands, Ship Construction and Navigation in Antiquity, the Middle Ages and in Modern Time*, BAR International Series, pages 75–84. Oxford.
- Barker, S. and Russell, B. (2012). Labour figures for Roman stone-working:

- pitfalls and potential. In Camporeale, S., Dessales, H., and Pizzo, A., editors, *Arqueología de la Construcción III. Los procesos constructivos en el mundo romano: la economía de las obras. Anejos de Archivo Español de Arqueología* 64, pages 83–94. Madrid and Merida.
- Barresi, P. (2003). *Province dell'Asia Minore: costodei marmi, architettura pubblica e committenza*. Studia Archaeologica. Rome.
- Barrico, L. and Subbrizio, M. (2007). L'indagine archeologica di piazza Vittorio Veneto a Torino. L'età romana. *Quaderni della Soprintendenza Archeologica del Piemonte*, 22:105–23.
- Bassetti, M., Capellozza, N., Cariboni, M., and Degasperri, N. (2013). Modificazioni geomorfologiche e aspetti geoarcheologici del territorio del sommolago. elementi per una ricostruzione del paesaggio. In Brogliolo, G., editor, *APSAT 3. Paesaggi storici del Sommolago*, pages 11–52. Mantua.
- Basso, P. (1987). *I miliari della Venetia romana*. Padua.
- Basso, P. (2008). I miliari della Cisalpina romana: considerazioni storico-epigrafiche. In Basso, P., Buonopane, A., Cavarzere, A., and Pesavento Mattioli, S., editors, *Est enim ille flos Italiae. Vita economica e sociale nella Cisalpina romana, Atti delle Giornate di Studi in onore di Ezio Buchi (Verona, 30 novembre - 1 dicembre 2006)*, pages 67–76. Verona.
- Basso, P. (2011). I miliari della Cisalpina romana: una lettura archeologica. In Basso, P., editor, *I miliari lungo le strade dell'impero. Atti del Convegno (Isola della Scala, 28 novembre 2010)*, pages 61–76. Verona.
- Basso, P. (2018). Cosa raccontano i cippi miliari. *Quaderni Friulani di Archeologia*, 28:107–21.
- Basso, P., Bonetto, J., Busana, M., and Michelini, P. (2004). La via Annia nella Tenuta Ca' Tron. In Busana, M. and Ghedini, F., editors, *La via Annia e le sue infrastrutture*, pages 41–98. Cornuda.
- Battistin, N. (2017). Anfore di produzione italic. In Fontana, F., editor, *Aquileia, l'insula tra foro e porto fluviale. Lo scavo dell'Università degli Studi di Trieste. 1. La Strada*, pages 385–404. Trieste.
- Bell, T., Wilson, A., and Wickham, A. (2002). Tracking the Samnites: Landscape and Communications Routes in the Sangro Valley, Italy. *American Journal of Archaeology*, 106(2):169–86.
- Beltrame, C. (1996). La *sutilis navis* del Lido di Venezia. Nuova testimonianza dell'antica tecnica cantieristica 'a cucitura' nell'alto Adriatico. In Ciciliot, F., editor, *Navalia. Archeologia e storia*, pages 31–53. Saronà.
- Beltrame, C. (2001). Imbarcazioni lungo il litorale altoadriatico occidentale, in età romana. Sistema idroviario, tecniche costruttive e tipi navali. *Antichità Altoadriatiche*, 46:431–49.

- Beltrame, C. (2002a). Le sutiles naves romane del litorale alto-adriatico. nuove testimonianze e considerazioni tecnologiche. In Gianfrotta, P. A. and Pelagatti, P., editors, *Archeologia subacquea. Studi, ricerche e documenti III*, pages 353–79. Rome.
- Beltrame, C. (2002b). Sewn plank boats of the Roman era in the upper Adriatic sea. New evidence. *Tropis*, 7:103–13.
- Beltrame, C. and Costa, E. (2016). A 5th-Century-AD Sewn-Plank River Barge at St Maria in Padovetere (Comacchio-FE), Italy: an interim report. *The International Journal of Nautical Archaeology*, 45:253–266.
- Beltrame, C. and Gaddi, D. (2013). Fragments of Boats from the Canale Anfora of Aquileia, Italy, and Comparison of Sewn-Plank Ships in the Roman Era. *The International Journal of Nautical Archaeology*, 43:296–304.
- Beltrame, C., Mozzi, P., Forti, A., Maritan, M., Rucco, A., Vavasori, A., and Miola, A. (2021). The Fifth-Century AD Riverine Barge of Santa Maria in Padovetere (Ferrara, Italy): A Multidisciplinary Approach to its Environment and Shipbuilding Techniques. *Environmental Archaeology*, 26(1):29–50.
- Beltrán Lloris, F. (2000). La vida en la frontera. In Beltrán Lloris, F., Martín-Bueno, M., and Pina Polo, F., editors, *Roma en la Cuenca Media del Ebro. La Romanización en Aragón*, pages 45–62. Zaragoza.
- Beltrán Lloris, M. (1982). El comercio vinario tarraconense en el valle del ebro: bases para su conocimiento. In Cultura, M. d., editor, *Concepción Fernández-Chicarro y de Dios, En homenaje a Conchita Fernández Chicarro*, pages 319–30. Madrid.
- Beltrán Lloris, M. (1983). El aceite en Hispania a través de las ánforas: la concurrencia del aceite itálico y africano. In María Blázquez, J. and Remesal Rodríguez, J., editors, *II Congreso Internacional sobre Producción y Comercio del Aceite en la Antigüedad*, pages 515–45. Madrid.
- Beltrán Lloris, M. (1987). El comercio del vino antiguo en el valle del Ebro. In *El vi a l'antiguitat. Economia, producció i comerç al Mediterrani occidental. I Colloqui d'arqueologia romana (Badalona, 1985)*., pages 51–74. Badalona.
- Beltrán Lloris, M. (1990). *Guía de la cerámica romana*. Zaragoza.
- Beltrán Lloris, M. (2008). Las ánforas tarraconenses en el valle del Ebro y la parte occidental de la Provincia Tarraconense. In López Mullor, A. and Aquilué Abadías, A., editors, *La producció i el comerç de les àmfores de la "Provincia Hispania Tarraconensis": Homenatge a Ricard Pascual i Guasch. Actes de les jornades d'estudi celebrades al Palau Marc de la Generalitat de Catalunya els dies 17 i 18 de novembre de 2005.*, page 271–318. Barcelona.
- Benito, G., Macklin, M., Zielhofer, C., Jones, A., and Machado, M. (2015). Holocene flooding and climate change in the Mediterranean. *Catena*, 130:13–

33.

- Bernard, H., Bessac, J.-C., Mardikian, P., and Feugère, M. (1998). L'épave romaine de marbre de Porto Nuovo. *Journal of Roman Archaeology*, 11:53–81.
- Bertacchi, L. (1976). L'imbarcazione romana di Montefalcone. *Antichità Altoadriatiche*, 10:39–45.
- Bertacchi, L. (1980). Il Porto Fluviale. In Tamaro, B., editor, *Da Aquileia a Venezia. Una mediazione tra l'Europa e l'Oriente dal II secolo a.C. al VI secolo d.C.*, pages 123–33. Milan.
- Bertacchi, L. (1990). Il sistema portuale della metropoli aquileiese. *Aquileia e l'arco adriatico Antichità Alto Adriatiche*, 36:227–53.
- Berti, F. (1990). Fortuna maris. *La nave romana di Comacchio*. Ferrara.
- Bes, P. (2015). *Once upon a Time in the East: The Chronological and Geographical Distribution of Terra Sigillata and Red Slip Ware in the Roman East*, volume 6 of *Roman and late antique Mediterranean pottery*. Oxford.
- Betori, A., Gomez Serito, M., and Pensabene, P. (2009). Investigations of Marbles and Stones Used in Augustan Monuments of Western Alpine Provinces (Italy). In Maniatis, Y., editor, *ASMOSIA VII. Proceedings of the 7th International Conference of Association for the Study of Marble and Other Stones in Antiquity. Thassos 15-20 september, 2003*, pages 89–102. Athens.
- Bevan, A. (2014). Mediterranean Containerization. *Current Anthropology*, 55(4):387–418.
- Bianchin Citton, E. and Balista, C. (1991). Megliadino S. Fidenzio. Località Giacomelli: stratificazioni re-sidue di un argine dell'età del bronzo connesse con un tratto di struttura spondale romana del paleoalveo dell'Adige (scavi 1985-1986). *Quaderni di Archeologia del Veneto*, 7:26–40.
- Bianco, L. (2008). La decorazione architettonica lapidea e marmorea. In Cavalieri Manasse, G., editor, *L'area del Capitolium di Verona. Ricerche storiche e archeologiche*, pages 169–14. Verona.
- Biancotti, A. (2001). Limiti dell'area di pianura. In Castiglioni, G. and Pellegrini, G., editors, *Note illustrative alla Carta Geomorfologica della Pianura Padana*, pages 17–19. Turin.
- Bini, M., Zanchetta, G., Regattieri, E., Isola, I., Drysdale, R. N., Fabiani, F., Genovesi, S., and Hellstrom, J. C. (2020). Hydrological changes during the Roman Climatic Optimum in northern Tuscany (Central Italy) as evidenced by speleothem records and archaeological data. *Journal of Quaternary Science*, 35(6):791–802.
- Biondani, F. (2005a). Anfore. In Mazzeo Saracino, L., editor, *Il complesso edilizio di età romana nell'area dell'ex Vescovado a Rimini*, pages 263–282. Florence.
- Biondani, F. (2005b). Terra sigillata africana. In Mazzeo Saracino, L., editor,

- Il complesso edilizio di età romana nell'area dell'ex Vescovado a Rimini*, pages 197–202. Florence.
- Biondani, F. (2005c). Terra sigillata italica. In Mazzeo Saracino, L., editor, *Il complesso edilizio di età romana nell'area dell'ex Vescovado a Rimini*, pages 171–74. Florence.
- Biondani, F. (2005d). Terra sigillata medioadriatica e tarda. In Mazzeo Saracino, L., editor, *Il complesso edilizio di età romana nell'area dell'ex Vescovado a Rimini*, pages 177–96. Florence.
- Biondani, F. (2005e). Terra sigillata orientale b. In Mazzeo Saracino, L., editor, *Il complesso edilizio di età romana nell'area dell'ex Vescovado a Rimini*, pages 169–70. Florence.
- Biondani, F. (2005f). Terra sigillata sud-gallica. In Mazzeo Saracino, L., editor, *Il complesso edilizio di età romana nell'area dell'ex Vescovado a Rimini*, pages 175–76. Florence.
- Biondani, F. (2008). Le Anfore Africane. In Cavalieri Manasse, G., editor, *L'Area del Capitolium di Verona. Ricerche Storiche e Archeologiche*, pages 387–404. Verona.
- Biondani, F. (2014). Terra sigillata medioadriatica ed altre ceramiche da mensa medio e tardoimperiali. In Mazzeo Saracino, L., editor, *Scavi di Suasa I. I reperti ceramici e vitrei dalla Domus dei Coiedii*, pages 251–92. Bologna.
- Blake, E. (2014). *Social Networks and Regional Identity in Bronze Age Italy*. Cambridge.
- Blanchard, P. and Volchenkov, D. (2009). *Mathematical analysis of urban spatial networks*. Berlin.
- Blouin, K. (2014). *Triangular landscapes: environment, society, and the state in the Nile Delta under Roman rule*. Oxford Studies on the Roman economy. Oxford.
- Bocchio, S. (2004). Anfore. In Mariotti, V., editor, *Il teatro e l'anfiteatro di Cividate Camuno: scavo, restauro, e allestimento di un parco archeologico*, pages 255–65. Florence.
- Bocconcello, S. (2008). Il Rivestimento Marmoree. In Cavalieri Manasse, G., editor, *L'Area del Capitolium di Verona. Ricerche Storiche e Archeologiche*, pages 233–53. Verona.
- Bockius, R. (2004). Ancient riverborne transport of heavy loads. In Pasquinucci, M. and Weski, T., editors, *Close Encounters: Sea and Riverborne Trade, Ports and Hinterlands, Ship Construction and Navigation in Antiquity, the Middle Ages and in Modern Time*, pages 105–115. Oxford.
- Bollati, I., Pelfini, M., and Smiraglia, C. (2017). Landscapes of Northern Lombardy: From the Glacial Scenery of Upper Valtellina to the Prealpine Lacus-

- trine Environment of Lake Como. In Soldati, M. and Marchetti, M., editors, *Landscapes and Landforms of Italy*, pages 89–99. Cham.
- Bondesan, M., Dal Cin, R., and Monari, R. (1990). L’ambiente in cui si arenò la nave romana di Comacchio: possibili modalità del suo naufragio e seppellimento. In Berti, F., editor, *Fortuna maris: la nave romana de Comacchio*, page 13. Bologna.
- Bondesan, M., Favero, V., and Viñals, M. (1995). New evidence on the evolution of the Po-delta coastal plain during the Holocene. *Quaternary international*, 29:105–10.
- Bonetto, J. (1997). *Le vie armentarie da Patavium alla montagna*. Dosson.
- Bonetto, J. and Busana, M. S. (1998). Argini e campagne nel Veneto romano: i casi del Terraglione di Vigo-darzere e dell’“Arzaron” di Este. *Quaderni di Archeologia del Veneto*, 14:88–94.
- Bonetto, J. and Previato, C. (2013). Trasformazioni del paesaggio e trasformazioni della città: le cave di pietra per Aquileia. *Antichità Altoadriatiche*, 43:141–62.
- Bongers, T. (2020). Connectivity in the Scheldt Basin: The role of the river Scheldt in the Roman-era transport network. *Digital Classics Online*, 6(1):33–58.
- Bonifay, M. (2003). La céramique africaine, un indice du développement économique? *Antiquité Tardive*, 11:113–28.
- Bonifay, M. (2004). *Études sur la céramique romaine tardive d’Afrique*. BAR International Series. Oxford.
- Bonifay, M. (2018). Distribution of African pottery under the Roman Empire: evidence vs. interpretation. In Wilson, A. I. and Bowman, A., editors, *Trade, Commerce, and the State in the Roman World*, Oxford Studies on the Roman Economy, pages 327–52. Oxford.
- Bonifay, M. and Tchernia, A. (2012). Les réseaux de la céramique africaine (IER-VE siècles). In Keay, S., editor, *Rome, Portus and the Mediterranean*, Archaeological Monographs of The British School at Rome, pages 315–33.
- Bonivento, C. (2017). Anfore di produzione africana. In Fontana, F., editor, *Aquileia, l’insula tra foro e porto fluviale. Lo scavo dell’Università degli studi di Trieste*, pages 425–44. Trieste.
- Bonivento, C. and Vecchiet, C. (2017a). Anfore di produzione iberica. In Fontana, F., editor, *Aquileia, l’insula tra foro e porto fluviale. Lo scavo dell’Università degli studi di Trieste*, pages 405–10. Trieste.
- Bonivento, C. and Vecchiet, C. (2017b). Anfore di produzione incerta o non identificabili. In Fontana, F., editor, *Aquileia, l’insula tra foro e porto fluviale. Lo scavo dell’Università degli studi di Trieste*, pages 445–48. Trieste.

- Bonivento, C. and Vecchiet, C. (2017c). Anfore di produzione orientale. In Fontana, F., editor, *Aquileia, l'insula tra foro e porto fluviale. Lo scavo dell'Università degli studi di Trieste*, pages 411–23. Trieste.
- Bonora Mazzoli, G. (1992). Tecnica Stradale nella Reggio XI: La Via Regina. *Atlante tematico di topografia antica*, 1:51–55.
- Borghi, A., Appolonia, L., L., F., and Zoja, A. (2006). The grey marble of Porta Praetoria (Aosta, Italy): a minero-petrographic characterisation and provenance determination. *Periodico di Mineralogia*, 75:59–74.
- Borghi, A., Vaggelli, G., Marcon, C., and Fiora, L. (2009). The Piedmont white marbles used in Antiquity : an archaeometric distinction inferred by a minero-petrographic and C-O stable isotope study. *Archaeometry*, 51(6):913–931.
- Bortolamei, F. and Bottos, M. (2017a). Terre sigillate africane. In Fontana, F., editor, *Aquileia, l'insula tra foro e porto fluviale. Lo scavo dell'Università degli Studi di Trieste.*, pages 271–83. Trieste.
- Bortolamei, F. and Bottos, M. (2017b). Terre sigillate e altre ceramiche fini orientali. In Fontana, F., editor, *Aquileia, l'insula tra foro e porto fluviale. Lo scavo dell'Università degli Studi di Trieste*, pages 267–69. Trieste.
- Bortolamei, F. and Bottos, M. (2017c). Terre sigillate italiane. In Fontana, F., editor, *Aquileia, l'insula tra foro e porto fluviale. Lo scavo dell'Università degli Studi di Trieste.*, pages 259–65. Trieste.
- Boscolo, F. (2015). Ateste romana: storia ed epigrafia negli ultimi vent'anni. *Epigraphica*, 76:337–70.
- Bosellini, A. (2017). Outline of the Geology of Italy. In Soldati, M. and Marchetti, M., editors, *Landscapes and Landforms of Italy*, pages 21–27. Cham.
- Bosi, G., Labate, D., Rinaldi, R., Montecchi, M. C., Mazzanti, M., Torri, P., Riso, F. M., and Mercuri, A. M. (2018). A survey of the Late Roman period (3rd-6th century AD): Pollen, NPPs and seeds/fruits for reconstructing environmental and cultural changes after the floods in Northern Italy. *Quaternary International*, pages 1–21.
- Bosi, G., Mazzanti, M., Florenzano, A., N'siala, I., Pederzoli, A., Rinaldi, R., Torri, P., and Mercuri, A. (2011). Seeds/fruits, pollen and parasite remains as evidence of site function: piazza Garibaldi – Parma (N Italy) in Roman and Medieval times. *Journal of Archaeological Science*, 38(7):1621–1633.
- Bosi, G., Mercuri, A., Bandini Mazzanti, M., Florenzano, A., Montecchi, M., Torri, P., Labate, D., and Rinaldi, R. (2015). The evolution of Roman urban environments through the archaeobotanical remains in Modena – Northern Italy. *Journal of Archaeological Science*, 53:19–31.
- Bosio, L. (1979). I *Septem Maria*. *Archeologia Veneta*, 2:33–44.
- Bosio, L. (1984). Capture la terra: La centurazione romana del Veneto. In Bussi,

- R. and Vandelli, V., editors, *Misurare le terra: Centuriazione e coloni nel mondo romano. Il caso Veneto*, pages 15–21. Modena.
- Bosio, L. (1991). *Le Strade Romane della Venetia e dell'Histria*. Padua.
- Botazzi, G. (1992). Le Vie Pubbliche Centurali tra Modena e Piacenza. *Atlante tematico di topografia antica*, 1:169–78.
- Botazzi, G. and Labate, D. (2017). Bonifiche idrauliche e centuriazione nel Modenese in età romana. Roman land drainage and centuriation within Modena and its surrounding territory. *Geologia dell'Ambiente*, 25:16–20.
- Bowman, A. and Wilson, A. (2009a). Quantifying the Roman Economy: Integration, Growth, Decline? In Bowman, A. and Wilson, A., editors, *Quantifying the Roman Economy: Methods and Problems*, Oxford Studies on the Roman Economy, pages 4–69. Oxford.
- Bowman, A. and Wilson, A. (2009b). *Quantifying the Roman economy: methods and problems*. Oxford Studies on the Roman Economy. Oxford.
- Bowman, A. and Wilson, A. (2011). *Settlement, urbanization, and population*. Oxford Studies on the Roman Economy. Oxford.
- Bowman, A. and Wilson, A. (2013). *The Roman Agricultural Economy: Organization, Investment, and Production*. Oxford Studies on the Roman Economy. Oxford.
- Braconi, P. (2009). Territorio e paesaggio dell'alta valle del Tevere in età romana'. In Coarelli, F. and Patterson, H., editors, *Mercator Placidissimus: The Tiber Valley in Antiquity. New research in the Upper and Middle river valley. Rome 27 - 28 February 2004*, pages 87–104. Rome.
- Bradley, M. (2013). Colour and marble in early imperial Rome. *The Cambridge Classical Journal*, 52:1–22.
- Brandolini, F. and Carrer, F. (2021). Terra, Silva et Paludes. Assessing the Role of Alluvial Geomorphology for Late-Holocene Settlement Strategies (Po Plain – N Italy) Through Point Pattern Analysis. *Environmental Archaeology*, 26:511–525.
- Brandolini, F. and Cremaschi, M. (2018). The Impact of Late Holocene Flood Management on the Central Po Plain (Northern Italy). *Sustainability*, 10(11):39–68.
- Brandon, C. J., Hohlfelder, R. L., Jackson, M. D., Oleson, J. P., and Bottalico, L. (2014). *Building for eternity: the history and technology of Roman concrete engineering in the sea*. Oxford.
- Bravard, J.-P. (2008). Impacts of climate change on the management of upland waters: the Rhône River case. In *Mountain Culture at the Banff Centre, Proceedings of the fifth Rosenberg International Forum on Water Policy*, pages 242–72. Banff.

- Brecciaroli Taborelli, L. (1978). Contributo alla classificazione di una terra sigillata chiara italica. *Rivista di Studi Marchigiani*, 1:1–38.
- Brecciaroli Taborelli, L. (1987a). Per una ricerca sul commercio della Transpadana occidentale in età romana: ricognizione sulle anfore di “Vercellae”. In Cresci, G., editor, *Atti del Convegno di Studi nel centenario della morte di L. Bruzza, 1883-1983, Vercelli. 1984*, pages 129–208. Vercelli.
- Brecciaroli Taborelli, L. (1987b). Un contributo alla conoscenza dell’impianto urbano di Eporedia (Ivrea): lo scavo di un isolato a Porta Vercelli. *Quaderni della Soprintendenza Archeologica del Piemonte*, 6:97–157.
- Brecciaroli Taborelli, L. (1990). Segusio: Nuovi dati e alcune ipotesi. *Quaderni della Soprintendenza Archeologica del Piemonte*, 9:65–157.
- Brecciaroli Taborelli, L. (1998). La villa suburbana di Eporedia (Ivrea). *Quaderni della Soprintendenza Archeologica del Piemonte*, 15:41–92.
- Brecciaroli Taborelli, L. (2007). Eporedia tra tarda repubblica e primo impero: Un aggiornamento. In Brecciaroli Taborelli, L., editor, *Forme e tempi dell’urbanizzazione nella Cisalpina (II secolo a.C.-I secolo d.C.): atti delle Giornate di studio: Torino, 4-6 maggio 2006*, pages 127–40. Florence.
- Brecciaroli Taborelli, L. and Gabucci, A. (2007). Le mura e il teatro di Augusta Taurinorum: sequenze stratigrafiche e dati cronologici. In Brecciaroli Taborelli, L., editor, *Forme e tempi dell’urbanizzazione nella Cisalpina (II secolo a.C.-I secolo d.C.): atti delle Giornate di studio: Torino, 4-6 maggio 2006*, pages 243–59. Florence.
- Bresson, A. (2005). Ecology and Beyond: The Mediterranean Paradigm. In Harris, W., editor, *Rethinking the Mediterranean*, pages 94–114. Columbia and Oxford.
- Bridge, J. (2003). *Rivers and Floodplains: Forms, Processes, and Sedimentary Record*. Oxford.
- Broadhead, W. (2000). Migration and Transformation in North Italy in the 3rd-1st Centuries BC. *Bulletin - Institute of Classical Studies*, 44(1):145–166.
- Broekaert, W. (2011). Partners in business: Roman merchants and the potential advantages of being a ‘collegiatus’. *Ancient society*, 41:221–256.
- Broekaert, W. (2013). *Navicularii et negotiantes: a prosopographical study of Roman merchants and shippers*. Rahden/Westf.
- Brogiolo, G. (1999). *Santa Giulia di Brescia: gli scavi dal 1980 al 1992: Reperti preromani, romani e altomedievali*. Florence.
- Brogiolo, G. (2015). Flooding in Northern Italy during the Early Middle Ages: Resilience and Adaptation. *The European Journal of Post Classical Archaeologies*, 5:47–68.
- Brogiolo, G. and Chavarría Arnau, A. (2018). Villas in Northern Italy. In

- Marzano, A. and Métraux, G., editors, *The Roman Villa in the Mediterranean Basin*, pages 178–94. Cambridge.
- Brogiolo, G. and Sarabia-Bautista, J. (2017). Land, rivers and marshes: changing landscapes along the Adige River and the Euganean Hills (Padua, Italy). *The European Journal of Post Classical Archaeologies*, 7:149–71.
- Brughmans, T. (2010). Connecting the dots: towards archaeological network analysis. *Oxford Journal of Archaeology*, 29:377–303.
- Brughmans, T. (2013). Thinking Through Networks: A Review of Formal Network Methods in Archaeology. *Journal of Archaeological Method and Theory*, 20(4):623–662.
- Brughmans, T. (2020). Evaluating the Potential of Computational Modelling for Informing Debates on Roman Economic Integration. In Verboven, K., editor, *Complexity Economics. Building a New Approach to Ancient Economic History*, Palgrave Studies in Ancient Economies, pages 105–23. Cham.
- Brughmans, T. (2022). Why simulate Roman economies? In Brughmans, T. and Wilson, A. I., editors, *Simulating Roman economies. Theories, methods and computational models*, Oxford Studies on the Roman Economy, pages 1–28. Oxford.
- Brughmans, T. and Pecci, A. (2020). An Inconvenient Truth. Evaluating the Impact of Amphora Reuse through Computational Simulation Modelling. In Duckworth, C. and Wilson, A., editors, *Recycling and Reuse in the Roman Economy*, pages 191–234. Oxford.
- Brughmans, T. and Poblome, J. (2016a). MERCURY: an agent-based model of tableware trade in the Roman East. *Journal of Artificial Societies and Social Simulation*, 19(1):3.
- Brughmans, T. and Poblome, J. (2016b). Roman bazaar or market economy? Explaining tableware distributions through computational modelling. *Antiquity*, 90:393–408.
- Brughmans, T. and Poblome, J. (2017). The case for computational modelling of the Roman economy: a reply to Van Oyen. *Antiquity*, 91:1364–66.
- Brughmans, T. and Wilson, A. I. (2022). *Simulating Roman economies. Theories, methods and computational models*. Oxford Studies on the Roman Economy. Oxford.
- Bruno, B. (1997). Contenitori da trasporto: i consumi di olio, vino e di altre derrate. In Filippi, F., editor, *Alba Pompeia. Archeologia della città dalla fondazione alla tarda antichità*, pages 516–32. Alba.
- Bruno, B. (1998). Importazione di merci e itinerari commerciali nella Liguria Transappenninica. Alcune considerazioni sulla presenza di anfore tra la fine del ii sec. A.C. e il ii sec. D.C. In Sena Chiesa, G., editor, *Optima via. Postumia*.

- Storia e archeologia di una grande strada romana alle radici dell'Europa*, pages 329–43. Venice.
- Bruno, B. (2002). Importazioni e consumo di derrate nel tempo: l'evidenza delle anfore. In Rossi, F., editor, *Nuove ricerche sul capitolium di Brescia. Scavi, studi e restauri*, pages 277–307. Milan.
- Bruno, B. (2005a). Le anfore da trasporto. In Gandolfi, D., editor, *La ceramica e i materiali di età romana. Classi, produzioni, commerci e consumi*, pages 353–94. Bordighera.
- Bruno, B. (2005b). Le anfore da trasporto. In Nobile De Agostini, I., editor, *Indagini archeologiche a Como. Lo scavo nei pressi della Porta Pretoria*, pages 129–42. Como.
- Bruno, B. (2008). Le anfore di media e tarda età imperiale di produzione italiana, egeo-orientale, ispanica e le anfore non identificate. In Cavalieri Manasse, G., editor, *L'area del Capitolium di Verona: ricerche storiche e archeologiche*, pages 373–86. Verona.
- Bruno, B. and Bocchio, S. (1991). Anfore. In Caporusso, D., editor, *Scavi MM3. Ricerche di archeologia urbana a Milano durante la costruzione della linea 3 della Metropolitana, 1982- 1990*, pages 259–97. Milan.
- Bruno, B. and Bocchio, S. (1999). Le Anfore da Trasporto. In Brogliolo, G., editor, *Santa Giulia di Brescia: gli scavi dal 1980 al 1992: Reperti preromani, romani e altomedievali*, pages 231–69. Florence.
- Bruno, L., Amorosi, A., Curina, R., Severi, P., and Bitelli, R. (2013). Human-landscape interactions in the Bologna area (northern Italy) during the mid-late Holocene, with focus on the Roman period. *The Holocene*, 23:1560–1571.
- Bruno, L., Piccin, A., Sammartino, I., and Amorosi, A. (2018). Decoupled geomorphic and sedimentary response of Po River and its Alpine tributaries during the last glacial/post-glacial episode. *Geomorphology*, 317:184–198.
- Brunt, P. (1971). *Italian Manpower 225 B.C.-A.D. 14*. Oxford.
- Brusić, Z. (1999). *Hellenistic and Roman Relief Pottery in Liburnia*. BAR. Oxford.
- Bucci, G. (2015). Padus, Sandalus, Gens Fadiena. Underwater Surveys in Palaeo-Watercourses (Ferrara District - Italy). *The International Archives of the Photogrammetry, Remote Sensing and Spatial Information Sciences*, XL-5/W5:55–60.
- Bucci, G. (2018). Remote Sensing and Geo-Archaeological Data: Inland Water Studies for the Conservation of Underwater Cultural Heritage in the Ferrara District, Italy. *Remote Sensing*, 10:1–21.
- Buchi, E. (1973). Banchi di anfore romane a Verona. Nota sui commerce cisalpine.

- In AA.VV, editor, *Il territorio veronese in età romana. Atti del convegno 1971*, pages 531–637. Verona.
- Bugini, R. and Folli (2016). Indentificazione dei frammenti marmorei. *Rivista archeologia dell'antica provincia e diocesi di Como*, 198:74–78.
- Buonopane, A. and Grossi, P. (2014). Costantino, i milari dell'Italia Settentrionale e la propaganda imperiale. *Antichità Altoadriatiche*, 78:161–77.
- Buora, M. (2001). La seconda edizione del *corpus vasorum arretinorum* e lo studio dei bolli relativi alla venetia e all'area transalpina. *Aquileia Nostra*, 62:241–300.
- Busana, M. (2008). Indagini nell'agro orientale di Altino: il popolamento in età romana tra Sile e Piave. *Atlante tematico di topografia antica*, 17:27–47.
- Busana, M., Bon, M., Cerato, I., Garavello, S., Ghiotto, A., Migliavacca, M., Nardi, S., Pizzeghello, D., and Zampieri, S. (2012). Agricoltura e allevamento nell'agro orientale di Altinum: il caso di Ca'Tron. In Busana, M. S. and Basso, P., editors, *La lana nella Cisalpina romana: economia e società. Atti del Convegno - Padova/Verona 18-20 maggio 2011*, pages 127–69. Padua.
- Busana, M., D'Incà, C., and Forti, S. (2009). Olio e pesce in epoca romana nell'alto e medio Adriatico. In Pesavento Mattioli, S. and Carre, M., editors, *Olio e pesce in epoca romana. Produzione e commercio nelle regioni dell'alto adriatico*, pages 37–81. Rome.
- Busana, M. S. and Forin, C. (2020). Economy and Production Systems in Roman Cisalpine Gaul: Some Data on Farms and Villae. In Marzano, A., editor, *Proceedings of the 19th International Congress of Classical Archaeology Volume 17: Villas, Peasant Agriculture, and the Roman Rural Economy*, pages 17–30. Heidelberg.
- Butti, F. (2016). La torre di via Parini e le mura di Como. *Rivista archeologia dell'antica provincia e diocesi di Como*, 198:47–120.
- Büntgen, U., Tegel, W., Nicolussi, K., McCormick, M., Frank, D., Trouet, V., Kaplan, J., Herzig, F., Heussner, K., Wanner, H., Luterbacher, J., and Esper, J. (2011). 2500 years of European climate variability and human susceptibility. *Science*, 331:578–82.
- Calzolari, M. (1992). Le Strade Romane della Bassa Padania. *Atlante tematico di topografia antica*, 1:161–68.
- Calzolari, M. (1995). Interventi di bonifica nella Padania centrale in età romana. *Atlante tematico di topografia antica*, 4:7–16.
- Calzolari, M. (2003). La diffusione dei marmi veronesi in età romana nell'Italia settentrionale: aspetti topografici. *Annuario storico della Valpolicella*, 19:169–84.
- Calzolari, M. (2004). *Il Po in età romana: Geografia, storia e immagine di un*

- grande fiume europeo*. Reggio Emilia.
- Calzolari, M. (2007). Il Delta Padano in Età Romana: idrografia, viabilità, insediamenti. In Berti, F., Bollini, M., Gelichi, S., and Ortalli, J., editors, *Genti nel delta da Spina a Comacchio: uomini, territorio e culto dall'antichità all'alto Medioevo*, pages 153–72. Ferrara.
- Campbell, B. (2012). *Rivers and the power of ancient Rome*. Chapel Hill.
- Camuffo, D. and Enzi, S. (1996). The analysis of two bi-millennial series: Tiber and Po river floods. In Jones, P., Bradley, R., and Jouzel, J., editors, *Climatic Variations and Forcing Mechanisms of the Last 2000 Years*, pages 433–50. New York.
- Caporusso, D. (1990). La situazione idrografica di Milano romana. In Silvana, editor, *Milano capitale dell'Impero romano 286-402 d.C*, pages 94–96. Milan.
- Caporusso, D. (1991a). La zona di corso di Porta Romana in età romana e medieval. In Caporusso, D., editor, *Scavi MM3. Ricerche di archeologia urbana a Milano durante la costruzione della linea 3 della metropolitana. 1982–1990 I*, pages 237–95. Milan.
- Caporusso, D. (1991b). *Scavi MM3. Ricerche di archeologia urbana a Milano durante la costruzione della linea 3*. Milan.
- Caramiello, R., Fossa, V., and Arobba, D. (2014a). Analisi archeopalinologiche nel sito romano di Pollentia. *Quaderni della Soprintendenza Archeologica del Piemonte*, 29:11–18.
- Caramiello, R., Fossa, V., Siniscalco, C., and Arobba, D. (2014b). La ricostruzione paleoambientale ad Augusta Bagiennorum in età romana. In Preacco, M., editor, *Augusta Bagiennorum. Storia e archeologia di una città augustea*, pages 66–77. Turin.
- Cardosa, M. (1996). I materiali pertinenti all'apparato decorativo della *domus*. In Pantò, G., editor, *Il Monastero della Visitazione a Vercelli. Archeologia e storia*, pages 223–34. Vercelli.
- Carre, M., Pesavento Mattioli, S., and Belotti, C. (2009). Le anforette da pesce adriatiche. In Pesavento Mattioli, S. and Carre, M., editors, *Olio e pesce in epoca romana. Produzione e commercio nelle regioni dell'alto Adriatico: Atti del Convegno (Padova, 16 febbraio 2007)*, pages 215–38. Rome.
- Carre, M. B. (2007a). L'évolution des importations à Aquilée. III. Les amphores orientales: données quantitatives comparées. *Antichità Altoadriatiche*, 65:583–604.
- Carre, M. B. (2007b). L'évolution des importations à Aquilée: Les nouvelles données de la fouille au nord du port fluvial. I. La periodisation. *Antichità Altoadriatiche*, 65:539–46.
- Carre, M. B., Monsieur, P., and Pesavento Mattioli, S. (2014). Transport am-

- phorae Lamboglia 2 and Dressel 6A: Italy and/or Dalmatia? Some clarifications. *Journal of Roman Archaeology*, 27:417–428.
- Carre, M. B. and Pesavento Mattioli, S. (2003). Tentativo di classificazione delle anfore olearie adriatiche. *Aquileia Nostra*, 74:454–475.
- Carreras, C. (1994a). *A Macroeconomic and Spatial Analysis of Long Distance Exchange: The Amphora Evidence from Roman Britain*. Thesis.
- Carreras, C. (1994b). *Una reconstrucción del comercio en cerámicas: la red de transportes en Britannia. Aplicaciones de modelos de simulación en PASCAL y SPANS*. Barcelona.
- Carreras, C. and De Soto, P. (2010). *Historia de la movilidad en la Península Ibérica: Redes de transporte en SIG*. Barcelona.
- Carreras, C. and De Soto, P. (2013). The Roman transport network: a precedent for the integration of the European mobility. *Journal of Quantitative and Interdisciplinary History*, 46(3):117–33.
- Carreras, C. and Morais, R. (2012). The Atlantic Roman trade during the principate. New evidence from the western façade. *Oxford Journal of Archaeology*, 31(4):419–441.
- Carton, A., Bondesan, A., Fontana, A., Meneghel, M., Miola, A., Mozzi, P., Primon, S., and Surian, N. (2009). Geomorphological evolution and sediment transfer in the Piave River system (northeastern Italy) since the Last Glacial Maximum. *Géomorphologie: relief, processus, environnement*, 3:155–74.
- Cary, E. and Foster, H. (1924). *Dio Cassius. Roman History. Vol. 7. Books 56–60*. Loeb Classical Library. Cambridge (MA).
- Carè, A. (2005). *L'ornato architettonico della Basilica di Massenzio*. Studia Archaeologia. Rome.
- Castillo, P. (2014). The Navigability of the River Ebro: A Reason for Roman Territorial Planning in the Ebro Valley. *Journal for Ancient Studies*, 3:129–52.
- Castro, F. and Capulli, M. (2016). A Preliminary report of recording the Stella 1 Roman River Barge, Italy. *The International Journal of Nautical Archaeology*, 45:29–41.
- Catarsi, M. (2007). Anfore. In Catarsi, M. and Malavasi, I., editors, *L'oltretorrente di Parma romana. Nuovi dati dallo scavo archeologico di Borgo Fornovo*, Quaderni di Archeologia dell'Emilia Romagna, pages 54–58. Parma.
- Catarsi, M. and Dall'Aglio, P. (1997). I ponti romani dell'Emilia occidentale. *Atlante tematico di topografia antica*, 2:209–21.
- Cattaneo, P. (1996). Ceramica a pareti sottili e terra sigillata dagli scavi di piazza Marconi a Cremona. In Facchini, G. M. and Passi Pitcher, L., editors, *Cremona e Bedriacum in età romana. I. Vent'anni di tesi universitarie*, pages 153–70. Milan.

- Cavada, E. (1995). *Materiali per la storia urbana di Tridentum*. ArchoAlp - Archeologia delle Alpi. Trento.
- Cavalieri Manasse, G. (1990). *Il monumento funerario romano di via Mantova a Brescia*. Rome.
- Cavalieri Manasse, G. (2008a). Il contesto urbanistico del santuario: l'area forense. In Cavalieri Manasse, G., editor, *L'area del Capitolium di Verona. Ricerche storiche e archeologiche*, pages 293–306. Verona.
- Cavalieri Manasse, G. (2008b). *L'Area del Capitolium di Verona. Ricerche Storiche e Archeologiche*. Verona.
- Cera, G. (1995). Scali portuali nel sistema idroviario padano in epoca romana. *Atlante tematico di topografia antica*, 4:179–98.
- Cera, G. (1996). Peculiari esempi di architettura strutturale in alcuni ponti della Venetia. *Atlante tematico di topografia antica*, 5:179–94.
- Cera, G. (2000). *La via Postumia da Genova a Cremona*. Atlante tematico di topografia antica. Supplemento. Rome.
- Charlin, G., J.M., G., and Lequément, R. (1978). L'épave antique de Cavalière. *Archaeonautica*, 2:9–93.
- Chevallier, R. (1976). *Roman Roads*. London.
- Chevallier, R. (1983). *La Romanisation de la Celtique du Pô*. Rome.
- Chilver, G. (1941). *Cisalpine Gaul: Social and Economic History from 49 B.C. to the Death of Trajan*. Oxford.
- Christie, N. (2006). *From Constantine to Charlemagne. An Archaeology of Italy AD 300-800*. Aldershot.
- Cioffi, R. (2016). Travel in the Roman World. *Oxford Handbooks*, pages 1–39.
- Cipolato, A. (2018). Anfore italiche, egeo-orientali e galliche. In Sperti, L., Tirelli, M., and Cipriano, S., editors, *Prima dello scavo. Il survey 2012 ad Altino*, pages 142–53. Venice.
- Cipriano, S. (2009). Le Anfore Olearie Dressel 6B. In Pesavento Mattioli, S. and Carre, M. B., editors, *Olio e pesce in epoca romana: produzione e commercio nelle regioni dell'Alto Adriatico: atti del convegno (Padova 16 febbraio 2007)*, pages 173–89. Rome.
- Cipriano, S. (2013). La terra sigillata. In Guarneri, C., editor, *Vivere a Forum Livi. Lo scavo di via Curte a Forlì*, pages 189–98. Bologna.
- Cipriano, S. (2016). Anfore Lamboglia 2, Dressel 6A e Dressel 6B dal Piazzale della Cattedrale di Iulia Concordia: nuovi dati. *Antichità Altoadriatiche*, 83:145–58.
- Cipriano, S. and Ferrarini, F. (2001). *Le anfore romane di Opitergium*. Oderzo.
- Cipriano, S. and Mazzocchin, S. (1998). Bonifiche con anfore a Padova: distribuzione topografica e dati cronologici. *Quaderni di Archeologia del Veneto*,

- 14:83–87.
- Cipriano, S. and Mazzocchin, S. (2004). La coltivazione dell’ulivo e la produzione olearia nella Decima Regio. Riflessioni su alcune serie bollate di anfore Dressel 6B alla luce delle analisi archeometriche. *Aquileia Nostra*, 75:93–120.
- Cipriano, S. and Mazzocchin, S. (2010). Un quartiere artigianale a Patavium. La fornace per la produzione di terra sigillata tardo-padana. *Rei Cretariæ Romanæ Fautorvm*, 41:141–53.
- Cipriano, S. and Mazzocchin, S. (2012). Produzioni anforarie dell’Italia Alto e Medio Adriatica in età romana. In Fioriello, S., editor, *Ceramica Romana nella Puglia Adriatica*, pages 241–54. Bari.
- Cipriano, S. and Mazzocchin, S. (2018). Sulla cronologia delle anfore Dressel 6A: novità dai contesti di bonifica della Venetia. *Rei Cretariæ Romanæ Fautorvm*, 45:261–71.
- Cipriano, S. and Mazzocchin, S. (2019). Dressel 6B and Dressel 6A’s oil and wine production in North Italy and the Adriatic western coast (1st century BC - 2nd century AD). In Remesal Rodríguez, J., Revilla Calvo, V., Martín-Arroyo Sánchez, D., and i Oliveras, A., editors, *Paisajes productivos y redes comerciales en el Imperio Romano/Productive Landscapes and Trade Networks in the Roman Empire*, pages 233–46. Barcelona.
- Cipriano, S., Mazzocchin, S., and Pastore, P. (1991). Novità e problematiche emergenti da un recente rinvenimento di anfore romane a Padova. *Quaderni di Archeologia del Veneto*, 7:163–74.
- Cipriano, S. and Sandrini, G. (2001). La banchina fluviale di Opitergium. *Antichità Altoadriatiche*, 46:289–94.
- Cipriano, S. and Sandrini, G. (2011). La terra sigillata bollata da Iulia Concordia: sintesi dei dati. *Quaderni Friulani di Archeologia*, 21:153–64.
- Cirelli, E. (2013). Roma sul mare e il porto augusteo di Classe. In Boschi, F., editor, *Ravenna e l’Adriatico dalle origini all’età romana*, pages 109–22. Bologna.
- Cisneros, M. (2018). Use and trade of ornamental rocks in the Mid-Ebro valley (Spain) in the Roman era. In Coquelet, C., Creemers, G., Dreesen, R., and Goemare, , editors, *Roman Ornamental Stones in North-Western Europe. Natural Resources, Manufacturing, Supply, Life After-Life*, pages 163–74. Jambes.
- Coarelli, F. and Patterson, H. (2009). Mercator Placidissimus: *The Tiber Valley in Antiquity: New Research in the Upper and Middle River Valley: Rome, 27-28 February 2004*. Rome.
- Collar, A. (2013). *Religious Networks in the Roman Empire: The Spread of New Ideas*. New York.
- Collar, A., Coward, F., Brughmans, T., and Mills, B. (2015). Networks in Ar-

- chaeology: Phenomena, Abstraction, Representation. *Journal of Archaeological Method and Theory*, 22(1):1–32.
- Combes, P., Mayer, T., and Thisse, J. (2008). *Economic Geography. The Integration of Regions and Nations*. Oxford.
- Cook, G. (1942). *Ennodius. Vita Epiphani*. Washington (DC).
- Cooper, J. (2011). No easy option: the Nile versus the Red Sea in ancient and mediaeval north-south navigation. In Harris, W. and Iara, K., editors, *Maritime Technology in the Ancient Economy*, pages 189–210. Portsmouth.
- Corbier, M. (1985). Dévaluation et évolution des prix, Ier - IIIe siècles. *Revue Numismatique*, 27:69–106.
- Corcoran, S. and DeLaine, J. (1994). The unit measurement of marble in Diocletian's Prices Edict. *Journal of Roman Archaeology*, 7:263–273.
- Corremans, M., Degryse, P., Wielgosz, D., and Waelkens, M. (2012). The import and use of white marble and coloured stone for wall and floor revetment at Sagalassos. In Garcia-M, A., Mercadal, P., and Rodà de Llanza, L., editors, *Interdisciplinary Studies on Ancient Stone. Proceedings of the IX Association for the Study of Marble and Other Stones in Antiquity (ASMOSIA) Conference (Tarragona 2009)*, pages 38–53. Tarragona.
- Corrò, E. and Mozzi, P. (2017). Water matters. Geoarchaeology of the city of Adria and palaeohydrographic variations (Po Delta, Northern Italy). *Journal of Archaeological Science*, 15:482–491.
- Corti, C. (2012a). Anfore d'età repubblicana (metà III-metà/fine I sec. a.C.). In Marini Calvani, M. and Marchi, A., editors, *Ventidue secoli a Parma : lo scavo sotto la sede centrale della Cassa di Risparmio in piazza Garibaldi*, BAR International Series, pages 115–21. Oxford.
- Corti, C. (2012b). Anfore di età proto imperiale e di prima e media età imperiale (metà/fine I secolo a.c. - I/II secolo d.c.). In Marini Calvani, M. and Marchi, A., editors, *Ventidue secoli a Parma : lo scavo sotto la sede centrale della Cassa di Risparmio in piazza Garibaldi*, BAR International Series, pages 182–83. Oxford.
- Corti, C. (2012c). Anfore di media e tarda età imperiale e di età alto medievale (fine II secolo d.c.-VI/VII secolo d.c.). In Marini Calvani, M. and Marchi, A., editors, *Ventidue secoli a Parma : lo scavo sotto la sede centrale della Cassa di Risparmio in piazza Garibaldi*, BAR International Series, page 202. Oxford.
- Covini, N. (2010). Strutture portuali e attraversamenti del Po: alcuni aspetti delle relazioni tra comunità, signori e stato ducale lombardo (secolo xv). In Olschki, L., editor, *La civiltà delle acque tra Medioevo e Rinascimento. Atti del Convegno internazionale, Mantova, 1-4 ottobre 2008.*, pages 243–59. Florence.
- Covizzi, C. (1996). Impianti produttivi. In Ambrosetti, G., Macellari, R., and Malnati, L., editors, *Lepidoregio. Testimonianze di età romana a Reggio Emilia*,

- pages 187–215. Reggio Emilia.
- Cremaschi, M. (2009). Foreste, terre coltivate e acque: L'originalità del progetto terramaricolo. In Bernarbò Brea, M. and Cremaschi, M., editors, *Acqua e civiltà nelle Terramare*, pages 34–42. Milan.
- Cremaschi, M., Mercuri, A. M., Benatti, A., Bosi, G., Brandolini, F., Clò, E., Florenzano, A., Furia, E., Mariani, G., Mazzanti, M., Montecchi, M. C., Rattighieri, E., Torri, P., and Zerboni, A. (2018). The SUCCESSO-TERRA Project: a Lesson of Sustainability from the Terramare Culture, Middle Bronze Age of the Po Plain (Northern Italy). *Interdisciplinaria archaeologica*, 9(2):221–229.
- Cremaschi, M., Mercuri, A. M., Torri, P., Florenzano, A., Pizzi, C., Marchesini, M., and Zerboni, A. (2016). Climate change versus land management in the Po Plain (Northern Italy) during the Bronze Age: New insights from the vp/vg sequence of the Terramara Santa Rosa di Poviglio. *Quaternary science reviews*, 136:153–172.
- Cremonini, S. (2002). Preliminary geomorphological and stratigraphic settings of a large Roman-age village near Maccaretolo (low alluvial plain between Bologna and Ferrara, Italy). *Mineral Periodical*, 71:125–36.
- Cremonini, S. (2003). Contesti stratigrafici del sito archeologico di Maccaretolo, Via Setti (S. Pietro in Casale, BO). Problemi geomorfologici e paleoambientali. In Cremonini, S., editor, *Maccaretolo: un pagus romano della pianura.*, pages 9–106. Bologna.
- Cremonini, S., Labate, D., and Curina, R. (2013). The late-antiquity environmental crisis in Emilia region (Po river plain, Northern Italy): Geoarchaeological evidence and paleoclimatic considerations. *Quaternary International*, 316:162–78.
- Cremonini, S. and Mattioli, S. (2017). Geomorfologia e poleogenesi nella VIII Regio augustea. Considerazioni sui siti urbani d'età antica. Geomorphology and poleogenesis in the Augustus' 8th region. Considerations on ancient urban sites. *Geologia dell'Ambiente*, 25:21–27.
- Cronon, W. (1991). *Nature's metropolis: Chicago and the Great West*. New York.
- Crosetto, A. (2013a). Tortona, il porto fluviale nella tarda antichità. In Lusuardi Siena, S., Gautierdi di Confiengo, E., and Tarrico, B., editors, *Il viaggio della fede. La cristianizzazione del Piemonte meridionale tra IV e VIII secolo (Atti del con-vegno, Cherasco - Bra - Alba 2010)*, pages 101–15. Carru.
- Crosetto, A. (2013b). Trasformazioni e continuità nel territorio delle antiche diocesi di Acqui, Tortona e Asti. In Lusuardi Siena, S., Gautierdi di Confiengo, E., and Tarrico, B., editors, *Il viaggio della fede. La cristianizzazione del Piemonte meridionale tra IV e VIII secolo (Atti del con-vegno, Cherasco -*

- Bra - Alba 2010*), pages 73–103. Carru.
- Curtis, D. and Campopiano, M. (2014). Medieval land reclamation and the creation of new societies: comparing Holland and the Po Valley, c.800-1500. *Journal of Historical Geography*, 44:93–108.
- D’Agostino, M. and Medas, S. (2010). Roman Navigation in Venice Lagoon: the Results of Underwater Research. *The International Journal of Nautical Archaeology*, 39:286–94.
- Dal Sie, E. (2018a). Terra sigillata gallica. In Sperti, L., Tirelli, M., and Cipriano, S., editors, *Prima dello scavo. Il survey 2012 ad Altino*, pages 77–81. Venice.
- Dal Sie, E. (2018b). Terra sigillata italica. In Sperti, L., Tirelli, M., and Cipriano, S., editors, *Prima dello scavo. Il survey 2012 ad Altino*, pages 64–68. Venice.
- Dal Sie, E. (2018c). Terra sigillata medi-adriatica e tarda. In Sperti, L., Tirelli, M., and Cipriano, S., editors, *Prima dello scavo. Il survey 2012 ad Altino*, pages 105–13. Venice.
- Dal Sie, E. (2018d). Terra sigillata nord-italica. In Sperti, L., Tirelli, M., and Cipriano, S., editors, *Prima dello scavo. Il survey 2012 ad Altino*, pages 69–79. Venice.
- Dall’Aglia, P., Ferrari, K., and Mete, G. (2012). Dalla città romana alla città tardoantica: trasformazioni e cambiamenti nelle città della pianura padana centro-occidentale. In do Carmo Ribeiro, M. and Sousa Melo, A., editors, *Evolução da paisagem urbana: sociedade e economia*, pages 69–98. Braga.
- Dall’Aglia, P. and Marchetti, G. (1991). Settlement Pattern and Agrarian Structures of the Roman Period in the Territory of Piacenza. In Barker, G. and Lloyd, J., editors, *Roman Landscapes: Archaeological Survey in the Mediterranean Region*, pages 160–68. London and Rome.
- Dallemulle, U. (1977). S. Basilio (Ariano Polesine). Seconda campagna di scavo, agosto 1978. *Padusa*, 12:113–24.
- Dannell, G. and Mees, A. (2013). New approaches to samian distribution. In Fulford, M. and Durham, E., editors, *Seeing Red: New Economic and Social Perspectives on Terra Sigillata*, pages 165–87. London.
- David, J.-M. (1997). *The Roman Conquest of Italy*. Oxford.
- De Bon, A. (1941). *Storia e leggende della terra veneta. I. Le strade del Diavolo*. Vicenza.
- De Sena, E. (2005). An assessment of wine and oil production in Rome’s hinterland: ceramic, literary, arthistorical and modern evidence. In Santillo Frizell, B. and Klynne, A., editors, *Roman Villas around the Urbs. Interaction with Landscape and Environment. Proceedings of a Conference at the Swedish Institute in Rome, September 17-19, 2004*, pages 135–49. Rome.
- De Soto, P. (2010). *Anàlisi de la xarxa de comunicacions i del transport a la*

- Catalunya romana: estudis de distribució i mobilitat*. Thesis.
- De Soto, P. (2019). Network Analysis to Model and Analyse Roman Transport and Mobility. In Verhagen, P., Joyce, J., and Groenhuijzen, M., editors, *Finding the Limits of the Limes. Modelling Demography, Economy and Transport on the Edge of the Roman Empire*, pages 271–90. Springer Open Access.
- De Soto, P. and Carreras, C. (2014). Gis and Network Analysis Applied to the Study of Transport in Roman Hispania. In Álvarez, J. M., Nogales, T., and Rodà, I., editors, *XVIII CIAC: Centro y periferia en el mundo clásico/Centre and periphery in the ancient world*, pages 733–38. Mérida.
- De Weerd, M. (1978). Ships of the Roman period at Zwammerdam/Nigrum Pullum, Germania Inferior. In du Plat Taylor, J. and Cleere, H., editors, *Roman Shipping and Trade. Britain and the Rhine Provinces*, CBA Research Report, pages 15–21. Hertford.
- Del Monte, M. (2017). The Typical Badlands Landscapes Between the Tyrrhenian Sea and the Tiber River. In Soldati, M. and Marchetti, M., editors, *Landscapes and Landforms of Italy*, pages 281–291. Cham.
- DeLaine, J. (1992). *Design and construction in Roman imperial architecture: the Baths of Caracalla in Rome*. Thesis.
- DeLaine, J. (1997). *The Baths of Caracalla: a Study in the Design, Construction, and Economics of Large-Scale Building Projects in Imperial Rome*. Portsmouth.
- DeLaine, J. (2015). The Pantheon Builders: Estimating Manpower for Construction. In Wilson Jones, M. and Marder, T., editors, *The Pantheon: From Antiquity to the Present*, pages 160–192. Cambridge.
- Della Porta, C. (1998). Terra sigillata di età alto e medio imperiale. In Olcese, G., editor, *Ceramiche in Lombardia tra II secolo a.C. e VII secolo d.C: Raccolta dei dati editi*, pages 81–124. Mantua.
- Desbat, A., Genin, M., and Lasfargues, J. (1996). Les productions des ateliers de potiers antiques de Lyon: 1ère partie : Les ateliers précoces. *Gallia*, 53:1–249.
- Descamps, C. (1992). L'épave antique de La Mirande a Port-Vendres. In Rieucou, J. and Cholvy, G., editors, *Le Languedoc, le Roussillon et la mer (des origines à la fin du XXe siècle)*, pages 79–97. Paris.
- Destro, C. (2015). *Decorazione architettonica lapidea nella provincia di Padova tra età di romanizzazione ed età giulio-claudia*. Thesis.
- Diosono, F. (2009). Il commercio del legname sul fiume Tevere. In Coarelli, F. and Patterson, H., editors, *Mercator Placidissimus: The Tiber Valley in Antiquity. New research in the upper and middle river valley. Rome 27 – 28 February 2004*, pages 251–83. Rome.
- Diosono, F. (2012). Paesaggio rurale, produzioni e commerci nella valle del Tevere in età tardoantica. In Bravi, A., editor, *Aurea Umbria: Una regione dell'Impero*

- nell'era di Costantino*, Bollettino per i beni culturali dell'Umbria, pages 199–209.
- Dobрева, D. (2013). Alcune osservazioni sul commercio e il consumo di derrate a Calvatone-Bedriacum. I dati dei contenitori da trasporto dell'area della *Domus del Labirinto* (2001-2006). In Grassi, M., editor, *Calvatone-Bedriacum. I nuovi scavi nell'area della Domus del Labirinto (2001-2006)*, pages 461–470. Mantua.
- Donat, P. (2015). Terra sigillata gallica in Italia nordorientale. Dalle collezioni museali alle scoperte recenti. *Quaderni Friulani di Archeologia*, 25:39–51.
- Donat, P. (2017). Terra Sigillata Gallica. In Maggi, P., Maselli Scotti, F., Pesavento Mattioli, S., and Zulini, E., editors, *Materiali per Aquileia: lo scavo di Canale Anfora (2004-2005)*, pages 101–08. Trieste.
- Donat, P. (2020). Nuove testimonianze di terra sigillata gallica dal territorio di Iulia Concordia e di Opitergium nella collezione archeologica di Pasiano di Pordenone. *Quaderni Friulani di Archeologia*, 30:121–29.
- Donat, P. and Maggi, P. (2017). Terre Sigillate Italiche. In Maggi, P., Maselli Scotti, F., Pesavento Mattioli, S., and Zulini, E., editors, *Materiali per Aquileia: lo scavo di Canale Anfora (2004-2005)*, pages 71–98. Trieste.
- Dragendorff, H. (1895). *Terra sigillata: Ein Beitrag zur Geschichte der griechischen und römischen Keramik*. Bonn.
- Dressel, H. (1879). *Di un grande deposito di anfore rinvenuto nel nuovo quartiere del Castro Pretorio (con tavole litografiche)*. Rome.
- Duch, M. (2017). *Economic role of the Roman army in the province of Lower Moesia (Moesia Inferior)*. Poznań.
- Duff, J. (1928). *Lucan. The Civil War (Pharsalia)*. Loeb Classical Library. Cambridge (MA).
- Duncan-Jones, R. (1974). *The Roman Economy: Quantitative Studies*. Cambridge.
- Duncan-Jones, R. (1978). Two possible indices of the purchasing power of money in Greek and Roman antiquity. *Publications de l'École Française de Rome*, 37(1):159–168.
- Duncan-Jones, R. (1982). *The Economy of the Roman Empire: Quantitative Studies*. Cambridge, second edition.
- Dyson, S. (1985). *The Creation of the Roman Frontier*. Princeton.
- Edgeworth, M. (2011). *Fluid Pasts: archaeology of flow*. London.
- Egri, M. (2007). The Use of Amphorae for Interpreting Patterns of Consumption. In Croxford, B., Ray, N., Roth, R., and White, N., editors, *TRAC 2006. Proceedings of the 16th Annual Theoretical Roman Archaeology Conference (Oxford 2007)*, pages 43–58. Oxford.
- Ehmig, U. (2010). *Dangstetten IV: die Amphoren*. Stuttgart.

- Erdkamp, P. (2012). A Forum on Trade: The Grain Trade in the Roman World. In Scheidel, W., editor, *The Cambridge Companion to the Roman Economy*, pages 304–308. Cambridge.
- Erdkamp, P., Verboven, K., and Zuiderhoek, A. (2015). *Ownership and exploitation of land and natural resources in the Roman world*. Oxford Studies on the Roman Economy. Oxford.
- Erim, K. and Reynolds, J. (1970). The Copy of Diocletian's Edict on Maximum Prices from Aphrodisias in Caria. *Journal of Roman Studies*, 60:120–141.
- Ettlinger, E., Hedinger, B., Hoffmann, B., Kenrick, P., Pucci, G., Roth-Rubi, K., Schneider, G., von Schnurbein, S., Wells, C., and Zabehlicky-Scheffenegger, S. (1990). *Conspectus formarum terrae sigillatae Italico modo confectae*. Bonn.
- Fabbri, B., Gualtieri, S., and Massa, S. (2004). Studio delle classi ceramiche: Aspetti archeologici e indagini archeometriche. In Mariotti, V., editor, *Il teatro e l'anfiteatro di Cividate Camuno: scavo, restauro, e allestimento di un parco archeologico*, pages 231–54. Florence.
- Facchini, G. and Leotta, F. (2005). Anfore. *Rivista archeologia dell'antica provincia e diocesi di Como*, 187:147–76.
- Facchini, G., Passi Pitcher, L., and Volonte, M. (1996). *Cremona e Bedriacum in età romana. Vent'anni di tesi universitarie*. Milan.
- Fairclough, H. (1999). *Virgil. Eclogues. Georgics. Aeneid: Books 1-6*. Loeb Classical Library. Cambridge (MA).
- Faletti, P., Gelati, R., and Rogledi, S. (1995). Oligo-Miocene evolution of Monferrato and Langhe, related to deep structures. In Polino, R. and Sacchi, R., editors, *Rapporti Alpi-appennino, Accademia Nazionale delle Scienze*, pages 1–19. Rome.
- Fant, J. (1999). Augustus and the city of marble. In Schvoerer, M., editor, *Archéomatériaux: marbres et autres roches. ASMOSIA IV.*, pages 277–80. Bordeaux.
- Fant, J., Russell, B., and Barker, G. (2013). Marble use and reuse at Pompeii and Herculaneum: the evidence from the bars. *Papers of the British School at Rome*, 81:181–209.
- Fentress, E. (1979). *Numidia and the Roman Army*. BAR International Series. Oxford.
- Fentress, E. (1990). The economy of an inland city: Sétif. In *L'Afrique dans l'occident romain Ier siècle av. J.-C. - IVe siècle ap. J.-C. Actes du colloque organisé par l'École française de Rome sous la patronage de l'Institut national d'archéologie et d'art de Tunis. (Rome 3-5 décembre 1987)*, pages 117–28. Rome.
- Fentress, E. (2013). Diana Veteranorum and the Dynamics of an Inland Economy.

- In Lavan, L., editor, *Local Economies? Production and Exchange of Inland Regions in Late Antiquity*, volume 10, pages 315–42. Leiden.
- Fentress, E., Fontana, S., and Hitchner, R. (2004). Accounting for ARS: fineware and sites in Sicily and Africa. In Alcock, S. and Cherry, J., editors, *Side-by-side survey: comparative regional studies in the Mediterranean world*, pages 147–62. Oxford.
- Fentress, J. and Fentress, E. (2001). Review: The Hole in the Doughnut. *Past and Present*, 107:203–19.
- Fernández Ochoa, C. and Morillo, A. (1994). *De Brigantium a Oiasso. Una aproximación al estudio de los enclaves marítimos cantábricos en época romana*. Madrid.
- Fernández Ochoa, C. and Morillo, C. (2010). Roman lighthouses on the Atlantic coast. In Carreras, C. and Morais, R., editors, *The Western Roman Atlantic Façade*, BAR International Series, pages 109–18. Oxford.
- Ferrari, C. (2017). Timberline and Alpine Vegetation in the Northern Apennines: Bioclimate Scenery and Vegetation Diversity. In Pedrotti, F., editor, *Climate Gradients and Biodiversity in Mountains of Italy*, pages 109–124. Cham.
- Filippi, F. (1995). Una coppa di sigillata africana figurata con il mito di Eracle e Kyknos da una tomba tardoromana di Alba Pompeia. *Quaderni della Soprintendenza Archeologica del Piemonte*, 13:59–72.
- Filippi, F. (1997). *Alba Pompeia. Archeologia della città dalla fondazione alla tarda antichità*. Alba.
- Finley, M. I. (1999). *The ancient economy*. Berkeley and London, updated edition, with a foreword by Ian Morris edition.
- Finné, M., Woodbridge, J., Labuhn, I., and Roberts, C. (2019). Holocene hydroclimatic variability in the Mediterranean: A synthetic multi-proxy reconstruction. *Holocene*, 29(5):847–63.
- Finocchi, S. (1980). Banchina Romana su Palificata. Trovata a Ivrea nell'alveo della Dora. In Piemonte, S. a. d., editor, *Studi di Archeologia dedicati a Pietro Barocelli*, pages 89–93. Turin.
- Fiorio, M. and Bandera Bistoletti, S. (1985). *Le chiese di Milano*. Milan.
- Flückiger, M., Hornung, E., Larch, M., Ludwig, M., and Mees, A. (2021). Roman Transport Network Connectivity and Economic Integration. *The Review of Economic Studies*, pages 1–71.
- Fontana, A. (2018). *Aquileia, l'insula tra foro e porto fluviale. Lo scavo dell'Università degli studi di Trieste*. Trieste.
- Fontana, A., Frassine, M., and Ronchi, L. (2020). Geomorphological and Geoarchaeological Evidence of the Medieval Deluge in the Tagliamento River (NE Italy). In Herget, J. and Fontana, A., editors, *Palaeohydrology: Traces, Tracks*

- and Trails of Extreme Events*, pages 97–116. Cham.
- Fontana, A., Mozzi, P., and Bondesan, A. (2008). Alluvial megafans in the Venetian–Friulian Plain (north-eastern Italy): Evidence of sedimentary and erosive phases during Late Pleistocene and Holocene. *Quaternary international*, 189(1):71–90.
- Fontana, A., Mozzi, P., and Marchetti, G. (2014). Alluvial fans and megafans along the southern side of the alps. *Sedimentary Geology*, 201:150–71.
- Fontana, F. (2017). *Aquileia, l’insula tra foro e porto fluviale. Lo scavo dell’Università degli Studi di Trieste*. Trieste.
- Forin, C. (2017). *Ville e fattorie nell’Italia settentrionale in epoca romana (II sec. a.C. – V sec. d.C.): architettura, economia e società*. Thesis.
- Foster, B. (1929). *Livy. History of Rome. Vol. V. Books 21-22*. Loeb Classical Library. Cambridge (MA).
- Fozzati, L. and Papotti, L. (1996). Nuove scoperte in Piedmont. *Atlante tematico di topografia antica*, 5:213–221.
- Framarin, P. and Castoldi, M. (2013). Lo studio dei materiali architettonici dall’area sacra del Foro di Augusta Praetoria. *Bollettino della Soprintendenza per i Beni e le Attività Culturali Regione Autonoma Valle d’Aosta*, 10:32–39.
- Franconi, T. (2013). Rome and the power of ancient rivers. Review. *Journal of Roman Archaeology*, 26:705–11.
- Franconi, T. (2014). *The Economic Development of the Rhine River Basin in the Roman Period (30 BC - AD 406)*. Thesis.
- Franconi, T. (2016). Climatic influences on riverine transport on the Roman Rhine. In Schäfer, C., editor, *Connecting the Ancient World. Mediterranean Shipping, Maritime Networks and their Impact (Pharos 35)*, pages 27–46. Rahden/Westf.
- Franconi, T. (2017a). *Pater Rhenus: the hydrological history of Rome’s German frontier*. In Franconi, T., editor, *Fluvial Landscapes in the Roman World*, pages 85–96. Portsmouth.
- Franconi, T. (2017b). Introduction: Studying Rivers in the Roman World. In Franconi, T., editor, *Fluvial Landscapes in the Roman World*, pages 7–22. Portsmouth.
- Fратиanni, S. and Acquaotta, F. (2017). The Climate of Italy. In Soldati, M. and Marchetti, M., editors, *Landscapes and Landforms of Italy*, pages 29–38. Cham.
- Fredi, P. and Lupia Palmieri, E. (2017). Morphological Regions of Italy. In Soldati, M. and Marchetti, M., editors, *Landscapes and Landforms of Italy*, pages 39–74. Cham.
- Frepoli, A. and Amato, A. (1997). Contemporaneous extension and compression

- in the Northern Apennines from earthquake fault-plane solutions. *Geophysical journal international*, 129(2):368–388.
- Frontori, I. (2017). *L'acqua a Mediolanum. Controllo e gestione delle risorse idriche in età romana*. Thesis.
- Frova, A. (1973). *Scavi di Luni: Relazione preliminare delle campagne di scavo, 1970-1971*. Rome.
- Fulford, M. (1987). Economic interdependence among urban communities of the Roman Mediterranean. *World Archaeology*, 19:58–75.
- Fulford, M. (2009). Approaches to Quantifying Roman Trade: A Response. In Wilson, A. I. and Bowman, A., editors, *Quantifying the Roman Economy: Methods and Problems*, Oxford Studies on the Roman Economy, pages 250–59. Oxford.
- Fulford, M. (2018). Procurators' Business? Gallo-Roman Sigillata in Britain in the Second and Third Centuries AD. In Wilson, A. and Bowman, A., editors, *Trade, Commerce, and the State in the Roman World*, Oxford Studies on the Roman Economy, pages 301–26. Oxford.
- Fulford, M. and Durham, E. (2013). *Seeing Red: new economic and social perspectives on terra sigillata*. Bulletin of the Institute of Classical Studies supplement. London.
- Gabba, E. (2001). Plinio Fraccaro e la storia antica. *Athenaeum*, 89:3–40.
- Gabelmann, H. (1973). *Die Werkstattgruppen der oberitalischen Sarkophage*. Bonn.
- Gabler, D. (1986). *Terra sigillata im Barbaricum zwischen Pannonien und Dazien*. Budapest.
- Gabucci, A. (1995). Marchi di fabbrica da Tortona. Terra sigillata italica, nord-italica e sud-gallica. *Quaderni della Soprintendenza Archeologica del Piemonte*, 13:29–58.
- Gabucci, A. (2017). *Attraverso le Alpi e lungo il Po: importazione e distribuzione di sigillate galliche nella Cisalpina*, volume 532. École française de Rome.
- Gabucci, A. and Mennella, G. (2003). Tra Emona e Augusta Taurinorum. Un mercante di Aquileia. *Aquileia Nostra*, 74:318–34.
- Gabucci, A., Mennella, G., and Pejrani Baricco, L. (2000). Un mercante di Aquileia tra 'Emona' e 'Augusta Taurinorum'. *Aquileia Nostra*, 71:522–24.
- Gabucci, A. and Quiri, E. (2008). Eporedia: Appunti su terre sigillate e anfore tra tarda repubblica e età imperiale. *Quaderni della Soprintendenza Archeologica del Piemonte*, 23:45–78.
- Gaddi, D. (2017). Anfore del Mediterraneo Occidentale. In Maggi, P., Maselli Scotti, F., Pesavento Mattioli, S., and Zulini, E., editors, *Materiali per Aquileia: lo scavo di Canale Anfora (2004-2005)*, pages 373–94. Trieste.

- Gaddi, D. and Maggi, P. (2017). Anfore Italiche. In Maggi, P., Maselli Scotti, F., Pesavento Mattioli, S., and Zulini, E., editors, *Materiali per Aquileia: lo scavo di Canale Anfora (2004-2005)*, pages 263–328. Trieste.
- Galvani, I. and Pellegrini, M. (2010). Navigare il Po, tra passato e futuro. In Ferrari, I. and Pellegrini, M., editors, *Un Po di carte. La dinamica fluviale dell'Ottocento e le tavole della Commissione Brioschi*, pages 51–65. Reggio Emilia.
- Gamba, M., Raimondi, N., and Rigoni, M. (2012). Vicenza, Dal Molin. Indagini sul contesto rustico e l'acquedotto romano (2009–2010). *Quaderni di Archeologia del Veneto*, 28:106–11.
- Gamberini, A. (2014). Anfore. In Mazzeo Saracino, L., editor, *Scavi di Suasa I. I reperti ceramici e vitrei dalla Domus dei Coiedii*, pages 533–86. Bologna.
- García Vargas, E., Almeida, R., and González Cesteros, H. (2011). Los tipos anfóricos del Guadalquivir en el marco de los envases hispanos del siglo I a.C. Un universo heterogéneo entre la imitación y la estandarización. *Spal*, 20:185–283.
- Gardner, A. (2007). *An Archaeology of Identity: Soldiers and Society in Late Roman Britain*. London.
- Garnsey, P. (1998). Economy and Society of Mediolanum under the Principate. In Scheidel, W., editor, *Cities, Peasants and Food in Classical Antiquity: Essays in Social and Economic History*, pages 45–62.
- Garnsey, P. and Saller, R. (1987). *The Roman Empire: economy, society and culture*. London.
- Gasperi, G. (2001). Schema strutturale dell'area. In Castiglioni, G. and Pellegrini, G., editors, *Note illustrative alla Carta Geomorfologica della Pianura Padana*, pages 45–54. Turin.
- Gerling, C., Doppler, T., Pike, A. W. G., Knipper, C., Heyd, V., Kuhn, T., Lehmann, M. F., and Schibler, J. (2017). The beginnings of alpine transhumance? Isotopic insights into neolithic cattle herding. *Chimia*, 71(12):860.
- Germinario, L., Zara, A., Maritan, L., Bonetto, J., Hanchar, J. M., Sassi, R., Siegesmund, S., and Mazzoli, C. (2018). Tracking trachyte on the Roman routes: Provenance study of Roman infrastructure and insights into ancient trades in northern Italy. *Geoarchaeology*, 33(4):417–29.
- Giacobelli, M. (1997). I vetri del relitto di Grado. In *Atti del Convegno Nazionale di Archaeologia Subaquea. Anzio, 30-31 maggio e 1 giugno 1996*, pages 311–13. Bari.
- Giardino, M., Mortara, G., and Chiarle, M. (2017). The Glaciers of the Valle d'Aosta and Piemonte Regions: Records of Present and Past Environmental and Climate Changes. In Soldati, M. and Marchetti, M., editors, *Landscapes*

- and Landforms of Italy*, pages 77–88. Cham.
- Golbeck, J. (2013). *Analyzing the Social Web*. Amsterdam.
- Gomez Serito, M. (2007). Caratterizzazione petrografica e indicazione delle aree di provenienza dei materiali lapidei. In Crosetto, A. and Gambari, M., editors, *Onde nulla si perda. La collezione archeologica di Cesare di Negro Carpani*, pages 335–40. Alessandria.
- Gomez Serito, M. (2019). I percorsi di pietre e marmi a valle e delle Alpi occidentali in età romana: uno sguardo di sintesi per la proposta di nuove letture sul territorio. In Mergozzo, G. A., editor, *Le Vie della pietra: estrazione e diffusione delle pietre da opera alpine dall'età romana all'età moderna. Atti del Convegno in occasione del decennale dell'Ecomuseo del Granito di Montorfano (28-29 Ottobre 2017)*, pages 105–18. Mergozzo.
- Gomez Serito, M. and Rulli, E. (2014). Le indagini petrografiche. In Preacco, M., editor, *Augusta Bagiennorum: storia e archeologia di una città augustea*, pages 140–47. Turin.
- Gonzalez Vilches, C., Gonzalez Rodriguez, M., Modrzewska, I., and Pianetti, F. (1998). Contenitori per garum e loro paste. Confronti fra Dr 7-12 dei ritrovamenti nel Veneto. *Archaeologia e Calcolatori*, 9:331–42.
- Gorrini, M. and Robino, M. (2015). The Sarcophagi of Ticinum (Pavia) A Preliminary Report. In Porod, B. and Koiner, G., editors, *Romische Sarkophage: Akten des Internationalen Werkstattgesprachs, 11.- 13. Oktober 2012 (Graz)*, pages 112–25. Graz.
- Graham, S. (2002). 'Ex Figlinis': *The Complex Dynamics of the Roman Brick Industry in the Tiber Valley during the 1st to 3rd Centuries AD*. Thesis.
- Graham, S. (2006). Networks, Agent-Based Models and the Antonine Itineraries: Implications for Roman Archaeology. *Journal of Mediterranean Archaeology*, 19(1):45–64.
- Graham, S. and Weingart, S. (2015). The Equifinality of Archaeological Networks: an Agent-Based Exploratory Lab Approach. *Journal of Archaeological Method and Theory*, 22(1):248–274.
- Grassi, M. (2013). *Calvatone-Bedriacum. I nuovi scavi nell'area della Domus del Labirinto (2001-2006)*,. Mantua.
- Grazia Maioli, M. (1990). La Topografica della zone di Classe. In Susini, G., editor, *Storia di Ravenna I*, pages 375–414. Ravenna.
- Grazia Maioli, M. (2018). Antiche acque di Ravenna. In Guarnieri, C. and Montevecchi, G., editors, *Il genio delle acque: scavi nelle piazze di Ravenna*, pages 331–42. Ravenna.
- Greci, R. (2016). Porti fluviali e ponti in età medievale. Il Po e l'area padana. *Hortus Artium Mediev.*, 22:238–48.

- Greene, K. (1986). *The Archaeology of the Roman Economy*. Berkeley and Los Angeles.
- Greene, K. (2005). Roman pottery: models, proxies, and economic interpretation. *Journal of Roman Archaeology*, 18:34–56.
- Greene, K. (2008). Learning to consume: consumption and consumerism in the Roman Empire. *Journal of Roman Archaeology*, 21:64–82.
- Gregoratti, L. (2015). Aquileian Families in Pannonia and Upper Moesia. In Tsetskhladze, G., Avram, A., and Hargrave, J., editors, *The Danubian Lands between the Black, Aegean and Adriatic Seas (7th Century BC-10th Century AD)*. *Proceedings of the Fifth International Congress on Black Sea Antiquities*, pages 219–22. Oxford.
- Grewe, K. (2009). Tunnels and Canals. In Oleson, J. P., editor, *The Oxford Handbook of Engineering and Technology in the Classical World*, volume 1, pages 329–36.
- Guarnieri, C. (2013a). I rivestimenti lapidei. In Guarnieri, C., editor, *Vivere a Forum Livi. Lo scavo di via Curte a Forlì*, pages 87–90. Bologna.
- Guarnieri, C. (2013b). *Vivere a Forum Livi. Lo scavo di via Curte a Forlì*. Bologna.
- Guarnieri, C. and Montevecchi, G. (2018). *Il genio delle acque: scavi nelle piazze di Ravenna*. Ravenna.
- Guarnieri, C., Montevecchi, G., and Pagani, C. (2018). La forma e l'evoluzione della *Domus*. In Guarnieri, C. and Montevecchi, G., editors, *Il Genio delle Acque. Scavi nelle piazze di Ravenna*, pages 88–90. Ravenna.
- Gumiero, B., Maiolini, B., Rinaldi, M., Surian, N., Boz, B., and Moroni, F. (2009). The Italian Rivers. In Tockner, K., Uehlinger, U., and Robinson, C., editors, *Rivers of Europe*, pages 467–95. Academic Press.
- Gunneweg, J., Perlman, I., and Yellin, J. (1983). *The provenience, typology, and chronology of Eastern Terra Sigillata*. Qedem. Jerusalem.
- Güimil-Fariña, A. and Parceró-Oubiña, C. (2015). “Dotting the joins”: a non-reconstructive use of Least Cost Paths to approach ancient roads. The case of the Roman roads in the NW Iberian Peninsula. *Journal of Archaeological Science*, 54:31–44.
- Hadfield, C. (1959). *British canals: an illustrated history*. London, revised edition.
- Haeussler, R. (2013). *Becoming Roman?: diverging identities and experiences in ancient northwest Italy*. Walnut Creek.
- Haldon, J., Elton, H., Huebner, S., Izdebski, A., Mordechai, L., and Newfield, T. (2018). Plagues, climate change, and the end of an empire: A response to Kyle Harper’s *The Fate of Rome: Disease, agency, and collapse*. *History compass*, 16(12).

- Harper, K. (2017). *Fate of Rome: Climate, Disease, and the End of an Empire*. Princeton.
- Harper, K. and McCormick, M. (2018). Reconstructing the Roman Climate. In Scheidel, W., editor, *The Science of Roman History. Biology, Climate, and the Future of the Past*, pages 11–52. Princeton.
- Harris, W. (1985). *War and Imperialism in Republican Rome, 327–70 B.C.* Oxford.
- Harris, W. (2000). A Julio-Claudian Business Family? *Zeitschrift für Papyrologie und Epigraphik*, 130:263–264.
- Harris, W. (2011a). Introduction. In Harris, W., editor, *Rome's Imperial Economy: Twelve Essays*, pages 1–12. Oxford, 2 edition.
- Harris, W. (2011b). Trade and the River Po: A Problem in the Economic History of the Roman Empire. In Harris, W., editor, *Rome's Imperial Economy: Twelve Essays*, pages 189–97. Oxford, 2 edition.
- Harris, W. and Ira, K. (2011). *Maritime Technology in the Ancient Economy: Ship-design and Navigation*. Portsmouth.
- Harris, W. V. (2007). The Late Republic. In Scheidel, W., Morris, I., and Saller, R., editors, *The Cambridge Economic History of the Greco-Roman World*, pages 511–39. Cambridge.
- Hayes, J. (1972). *Late Roman Pottery*. London.
- Hayes, J. (2005). Late Hellenistic and Roman pottery in the eastern Mediterranean: an overview of recent developments. In Berg Briese, M. and Vaag, L., editors, *Trade relations in the eastern Mediterranean from the Late Hellenistic period to Late Antiquity: the ceramic evidence*, pages 11–26. Odense.
- Hayes, J. (2008). *Roman pottery: fineware imports*. The Athenian agora: results of excavations conducted by the American School of Classical Studies at Athens. Princeton, N.J.
- Heckscher, E. and Ohlin, B. (1991). *Heckscher-Ohlin Trade Theory*. Boston.
- Hitchner, R. (2005). *Globalizing Roman Culture: Unity, Diversity and Empire*. London.
- Hitchner, R. (2012). Roads, Integration, Connectivity, and Economic Performance in the Roman Empire. In Alcock, S., Bodel, J., and Talbert, R., editors, *Highways, byways, and road systems in the pre-modern world*, page 222–34. New York.
- Hobson, M. (2015). *The North African boom: evaluating economic growth in the Roman province of Africa Proconsularis (146 B.C. - A.D. 439)*. Portsmouth, Rhode Island.
- Hollis, A. (2007). *Fragments of Roman Poetry c.60 BC–AD 20*. Oxford.
- Hooper, W. and Ash, H. (1934). *Cato, Varro. On Agriculture*. Loeb Classical

- Library. Cambridge (MA).
- Hopkins, K. (1980). Taxes and Trade in the Roman Empire (200 B.C. – A.D. 400). *Journal of Roman Studies*, 70:101–25.
- Hopkins, K. (1996). Rome, taxes, rents and trade. *Kodai*, 6:41–75.
- Horden, P. and Purcell, N. (2000). *The Corrupting Sea: A Study of Mediterranean History*. Oxford.
- Häussler, R. (2007). At the Margins of Italy: Celts and Ligurians in North-West Italy. In Bradley, G., Isayev, E., and Riva, C., editors, *Ancient Italy: Regions without Boundaries*, pages 45–78. Exeter.
- Isaksen, L. (2008). The application of network analysis to ancient transport geography: A case study of Roman Baetica. *Digital Medievalist*, 4.
- Izdebski, A., Holmgren, K., Weiberg, E., Stocker, S., Büntgen, U., Florenzano, A., Gogou, A., Leroy, S., Luterbacher, J., Martrat, B., Masi, A., Mercuri, A., Montagna, P., Sadori, L., Schneider, A., Sicre, M., Triantaphyllou, M., and Xoplaki, E. (2016). Realising consilience: How better communication between archaeologists, historians and natural scientists can transform the study of past climate change in the Mediterranean. *Quaternary Science Reviews*, 136:5–22.
- Joncheray, A. and Joncheray, J.-P. (2007). Chrétienne M, trois épaves distinctes, entre le cinquième siècle avant et le premier siècle après Jésus-Christ. *Cahiers d'Archéologie Subaquatique*, 14:57–130.
- Jones, E. (2000). River navigation in Medieval England. *Journal of Historical Geography*, 26(1):60–75.
- Jongman, W. (2002). The Roman economy: from cities to empire. In De Blois, L. and Rich, J., editors, *The transformation of economic life under the Roman empire*, pages 28–47. Amsterdam.
- Jorio, S. (1991). Terra Sigillata. In Caporusso, D., editor, *Scavi MM3. Ricerche di archeologia urbana a Milano durante la costruzione della linea 3*, pages 57–87. Milan.
- Jorio, S. (1998). Terra sigillata di età medio e tardo imperiale. In Olcese, G., editor, *Ceramiche in Lombardia tra II secolo a.C. e VII secolo d.C: Raccolta dei dati editi*, pages 125–32. Mantua.
- Jorio, S. (1999). Le Terra Sigillate di Produzione non Africana. In Brogliolo, G., editor, *Santa Giulia di Brescia: gli scavi dal 1980 al 1992: Reperti preromani, romani e altomedievali*, pages 81–95. Florence.
- Jorio, S. (2000). Terra sigillata: manufatture "locali" e importazioni nella documentazione di alcuni scavi milanesi. In La Guardia, R., Tibiletti, T., and Ridi, C., editors, *Milano tra l'età repubblicana e l'età augustea, Atti del Convegno di Studi 26-27 marzo 1999, Milano*, pages 99–109. Milan.
- Jorio, S. (2002). Terra sigillata della media e tarda età imperiale di produzione

- padana. Contributo alla definizione di un repertorio lombardo. In Rossi, F., editor, *Nuove ricerche sul Capitolium di Brescia: scavi, studi e restauri*, pages 323–52. Milan.
- Kajanto, I. (1982). *The Latin Cognomina*. Rome.
- Karagiorgu, O. (2001). Lr2: a Container for the Military annona on the Danubian Border? In Kingsley, S. and Decker, M., editors, *Economy and exchange in the East Mediterranean during Late Antiquity : proceedings of a conference at Somerville College, Oxford - 29th May, 1999*, pages 129–66. Oxford.
- Keay, S. (1984). *Late Roman amphorae in the western Mediterranean*. Oxford.
- Keay, S. (2012). *Portus and the Ports of the Roman Mediterranean*. Archaeological Monographs of the British School at Rome. Rome and London.
- Kenrick, P. (1993). Italian Terra Sigillata: a sophisticated Roman industry. *Oxford Journal of Archaeology*, 12:235–42.
- Kenrick, P. (2000). Stamped Sigillata from Northern Italy: Patterns of Distribution. In Brogliolo, G. and Olcese, G., editors, *Produzione ceramica in area padana tra il II secolo a.C. e il VII secolo d.C: nuovi dati e prospettive di ricerca: convegno internazionale, Desenzano del Garda, 8-10 aprile 1999*, pages 47–52. Mandova.
- Kleineberg, A. (2021). The *Capitolium* at Brescia in the Flavian Period. In Haug, A. and Lauritsen, M., editors, *Principles of Decoration in the Roman World*, pages 71–90. Berlin and Boston.
- Klostermann, J. (2001). Klima und Landschaft am römischen Niederrhein. In Grünewald, T. and Schalles, H.-J., editors, *Germania Inferior: Besiedlung, Gesellschaft und Wirtschaft an der Grenze der römisch-germanischen Welt*, pages 36–53. Berlin.
- Knappett, C. (2013). Introduction: Why Networks? In Knappett, C., editor, *Network Analysis in Archaeology: New Approaches to Regional Interaction*, pages 3–15. Oxford.
- Knoke, D. and Yang, S. (2008). *Social network analysis*. Quantitative applications in the social sciences ; 154. Los Angeles, second edition. edition.
- Koščević, R. and Makjanić, R. (1995). *Siscia Pannonia Superior: Finds and Metalwork Production. Terra Sigillata*. BAR. Oxford.
- Krugman, P. (1991). *Geography and Trade*. Boston.
- Labate, D. (2019). Archeologia di una strada consolare: la via Emilia dalla fondazione all’età contemporanea. *Atlante tematico di topografia antica*, 29:195–212.
- Labuhn, I., Finné, M., Izdebski, A., Roberts, N., and Woodbridge, J. (2016). Climatic Changes and Their Impacts in the Mediterranean during the First Millennium AD. *Late Antique Archaeology*, 12(1):65–88.

- Langdon, J. (2000). Inland water transport in Medieval England—the view from the mills: a response to Jones. *Journal of Historical Geography*, 26(1):75–82.
- Laubenheimer, F. (1985). *La production des amphores en Gaule Narbonnaise*. Paris.
- Laubenheimer, F. (1991). Les vides sanitaires et les amphores de la Porte d'Oree a Fréjus. *Gallia*, 48:229–66.
- Laubenheimer, F. (2001). Le vin gaulois de Narbonnaise exporté dans le monde romain. *Vingt ans de recherches à Sallèles d'Aude*, 760:51–66.
- Laubenheimer, F., Gébara, C., and Béraud, I. (1992). Circulation des amphores et vide sanitaire, l'exemple de Fréjus. *Collection de l'Institut des Sciences et Techniques de l'Antiquité*, 472:119–22.
- Laurence, R. (1999). *The roads of Roman Italy: mobility and cultural change*. London and New York.
- Laurence, R. (2005). Land transport in Roman Italy: costs, practice and the economy. In Parkins, H. and Smith, C., editors, *Trade, Traders and the Ancient City*, pages 129–147. London.
- Laurence, R. and Trifilò, F. (2015). The Global and Local in the Roman Empire: connectivity and mobility from an urban perspective. In Pitts, M. and Versluys, J., editors, *Globalisation and the Roman world: world history, connectivity and material culture*, pages 99–122. Cambridge.
- Lavan, L. (2015a). Local Economies in Late Antiquity? Some Thoughts. In Lavan, L., editor, *Local Economies? Production and Exchange of Inland Regions in Late Antiquity*, pages 1–11. Leiden.
- Lavan, L. (2015b). *Local Economies?: Production and Exchange of Inland Regions in Late Antiquity*. Leiden.
- Laven, P. (1989). The Venetian rivers in the Sixteenth Century. In Bergier, J., editor, *Montagnes, fleuves, forêts dans l'histoire*, pages 198–217. St. Katherinen.
- Lavizzari Pedrazzini, M. (1973a). Ceramica arretina, T.S. tardo-italica, T.S. gallica. In Frova, A., editor, *Scavi di Luni: Relazione preliminare delle campagne di scavo, 1970-1971*, pages 698–701. Rome.
- Lavizzari Pedrazzini, M. (1973b). Ceramica arretina, T.S. tardo-italica, T.S. gallica, T.S. italica (D). In Frova, A., editor, *Scavi di Luni: Relazione preliminare delle campagne di scavo, 1970-1971*, pages 283–331. Rome.
- Lavizzari Pedrazzini, M. (2003). Osservazioni in margine alla terra sigillata gallica rinvenuta a Torino. In Mercado, L., editor, *Archeologia a Torino*, pages 246–57. Turin.
- Lazzarini, L. (2004). Archaeometric aspects of white and coloured marbles used in antiquity: the state of the art. *Periodico di Mineralogia*, 73:113–25.

- Lazzarini, L. (2019). Ancient Mediterranean polychrome stones. In Artioli, G. and Oberti, R., editors, *The Contribution of Mineralogy to Cultural Heritage*, pages 367–392. Twickenham.
- Leitch, V. (2011). Location, location, location: characterizing coastal and inland production and distribution of Roman African cooking wares. In Robinson, D. and Wilson, A. I., editors, *Maritime Archaeology and Ancient Trade in the Mediterranean*, pages 167–92. Oxford.
- Leitch, V. (2013). Reconstructing history through pottery: the contribution of Roman N African cookwares. *Journal of Roman Archaeology*, 26:281–306.
- Leka, E. and Zachos, G. (2015). The *marmor lesbium* reconsidered and other stones of lesbos. In Pensabene, P. and Gasparini, E., editors, *ASMOSIA X: proceedings of the tenth International Conference of ASMOSIA, Association for the Study of Marble Other Stones in Antiquity, Rome, 21-26 May 2012*, pages 201–11. Rome.
- Leleković, T. (2018). How were Imitations of Samian Formed? *Internet Archaeology*, 50.
- Leveau, P. (1999). Le Rhône romain: dynamiques fluviales, dynamiques territoriales. *Gallia*, 56:1–175.
- Lewit, T. (2015). The lessons of Gaulish sigillata and other finewares. In Lavan, L., editor, *Local Economies? Production and Exchange of Inland Regions in Late Antiquity*, volume 10, pages 227–257. Leiden.
- Limão, N. and Venables, A. (2001). Infrastructure, Geographical Disadvantage, Transport Costs, and Trade. *The World Bank Economic Review*, 15(3):451–479.
- Lindhagen, A. (2009). The transport amphoras Lamboglia 2 and Dressel 6A: a central Dalmatian origin? *Journal of Roman Archaeology*, 22(1):83–108.
- Liu, J. (2009). *Collegia Centonariorum: The Guilds of Textile Dealers in the Roman West*. Leiden.
- Livarda, A. and Orenco, H. (2015). Reconstructing the Roman London flavourscape: new insights into the exotic food plant trade using network and spatial analyses. *Journal of Archaeological Science*, 55:244–52.
- Lo Cascio, E. (2009). *Crescita e Declino: studi di storia dell'economia romana*. Rome.
- Lo Cascio, E. (2018). Market Regulation and Transaction Costs in the Roman Empire. In Wilson, A. I. and Bowman, A., editors, *Trade, Commerce, and the State in the Roman World*, Oxford Studies on the Roman Economy, pages 117–32. Oxford.
- Lomas, K. (2017). The Veneti. In Farney, G. and Bradley, G., editors, *The Peoples of Ancient Italy*, pages 701–18. Berlin and Boston.

- Lucchese, L. (2004). I ponti romani di Pont-Saint-Martin, Bard, Saint-Vincent, Châtillon, Aosta e Lévêrogne. *Atlante tematico di topografia antica*, 12:7–23.
- Lund, J. (2003). Eastern sigillata b : a ceramic fineware industry in the political and commercial landscape of the eastern mediterranean. *Publications de l'Institut Français d'Études Anatoliennes*, 15(1):125–36.
- Mackensen, M. and Schneider, G. (2002). Production centres of African red slip ware (3rd-7th c.) in northern and central Tunisia: archaeological provenance and reference groups based on chemical analysis. *Journal of Roman Archaeology*, 15:121–158.
- Macklin, M., Lewin, J., and Woodward, J. (2012). The fluvial record of climate change. *Philosophical Transactions: Mathematical, Physical and Engineering Sciences*, 370:2143–72.
- Madricardo, F., Bassani, M., D'Acunto, G., Calandriello, A., and Foglini, F. (2021). New evidence of a Roman road in the Venice Lagoon (Italy) based on high resolution seafloor reconstruction. *Nature. Scientific Reports*, 11(1):13985–13985.
- Maggi, P., Maselli Scotti, F., Pesavento Mattioli, S., and Zulini, E. (2017). *Materiali per Aquileia: lo scavo di Canale Anfora (2004-2005)*. Trieste.
- Magie, D. (1932). *Historia Augusta. Vol. 3. The Two Valerians. The Two Gallieni. The Thirty Pretenders. The Deified Claudius. The Deified Aurelian. Tacitus. Probus. Firmus, Saturninus, Proculus and Bonosus. Carus, Carinus and Numerian*. Loeb Classical Library. Cambridge (MA).
- Malizia, A. (1986). Oderzo. Rinvenimento nel canale Navisego. *Quaderni di Archeologia del Veneto*, 2:86–88.
- Mantovani, V. (2013). *Aspetti della produzione e del commercio dell'Instrumentum domesticum di età romana ad Adria, alla luce dei rinvenimenti di via Retratto*. Thesis.
- Mantovani, V. (2018). Recenti studi sulle sigillate galliche in area padana: alcune riflessioni. *Quaderni Friulani di Archeologia*, 28:179–84.
- Manzelli, V. (2000). Documentazione Archeologia. *Atlante tematico di topografia antica*, 8:39–196.
- Marchetti, G. and Dall'Aglio, P. (1990). Parte II: antropizzazione ed evoluzione fisica del territorio. In *Storia di Piacenza. I. Dalle origini all'anno Mille*, pages 604–85. Milan.
- Marchetti, M. (2002). Environmental changes in the central Po Plain (Northern Italy) due to fluvial modifications and anthropogenic activities. *Geomorphology*, 22:361–73.
- Marchi, E., Roth, G., and Siccardi, F. (1995). The Po: Centuries of River Training. *Physics and Chemistry of the Earth*, 20:475–78.

- Marchiori, A. (1990). Sistemi portuali della Venetia Romana. *Antichità Altoadriatiche*, 36:197–225.
- Marengo, S. (2003). Donne e produzione: esempi della *regio V*. In Buonapane, A. and Cenerini, F., editors, *Donna e lavoro nella documentazione epigrafica, Atti del I Seminario sulla condizione femminile nella documentazione epigrafica, Bologna 2002*, pages 75–86. Faenza.
- Marini Calvani, M. (1981). *Per la Val Baganza, numero unico del Centro Studi della Val Baganza*. Baganza.
- Marini Calvini, M. (1985). Piacenza in età romana. In Pontiroli, G., editor, *Cremona romana. Atti del Congresso storico archeologico per il 2200 anno di fondazione di Cremona*, pages 261–73. Cremona.
- Marini Calvini, M. (1999). Strade Romane dell’Emilia Occidentale. *Atlante tematico di topografia antica*, 8:187–92.
- Mariotti, V. (2004). *Il teatro e l’anfiteatro di Cividate Camuno: scavo, restauro, e allestimento di un parco archeologico*. Florence.
- Mariotti, V., Massa, S., and Ravasi, T. (2008). Cremona, dal fiume alla città: materiali da due scavi degli Anni Ottanta. In *Notarizo 2006, Soprintendenza per i Beni Archeologia della Lombardia*, pages 193–208. Milan.
- Mariottini, M. (1998). La provenienza dei marmi cristallini usati in antico: un problema aperto. In Pensabene, P., editor, *Marmi Antichi II*, pages 115–31. Rome.
- Maritan, L., Mazzoli, C., and Mazzocchin, S. (2019). Provenance of wine and oil amphorae in northern Adriatic: archaeometric and epigraphic approaches. *Archéosciences*, pages 203–210.
- Maritan, L., Secco, M., Mazzoli, C., and Mantovani, V. (2013). The decorated Padan terra sigillata from the site of Retratto, Adria (north-eastern Italy): Provenance and production technology. *Applied Clay Sciences*, 82(1):62–69.
- Marlière, E. (2001). Le tonneau en Gaule romaine. *Gallia*, 58:181–201.
- Marsden, P. (1967). *A ship of the Roman period, from Blackfriars, in the City of London*. London.
- Martin, R. (2006). Economic geography and the new discourse of regional competitiveness. In Bagchi-Sen, S. and Lawton Smith, H., editors, *Economic Geography. Past, present, and future*, pages 159–72. Oxon.
- Marzano, A. (2007). *Roman Villas in Central Italy: A Social and Economic History*. Leiden and Boston.
- Maselli Scotti, F. (2017). Terra Sigillata Orientale. In Maggi, P., Maselli Scotti, F., Pesavento Mattioli, S., and Zulini, E., editors, *Materiali per Aquileia: lo scavo di Canale Anfora (2004-2005)*, pages 109–14. Trieste.
- Massa, S. (1999). La Ceramica d’Importazione Africana. In Brogliolo, G., editor,

- Santa Giulia di Brescia: gli scavi dal 1980 al 1992: Reperti preromani, romani e altomedievali*, pages 101–17. Florence.
- Massa, S. (2002). La ceramica d'importazione africana. In Rossi, F., editor, *Nuove ricerche sul Capitolium di Brescia: scavi, studi e restauri*, pages 371–79. Milan.
- Massensini, G. (1973). Note sui resti di un antico porto a Padenghe sul Garda. *Benaco*, 1:518–27.
- Masseroli, S. (1997). Anfore. In Sena Chiesa, G., Masseroli, S., Medici, T., and Volonte, M., editors, *Calvatone romana. Un pozzo e il suo contesto. Saggio nella zona nord dell'area di proprietà provinciale*, pages 91–107. Milan.
- Mateazzi, M. (2009). Costruire strade in epoca romana: tecniche e morfologie. Il caso dell'Italia settentrionale. *Exedra*, 1:17–38.
- Mattingly, D. (1988). Oil for export? A comparison of Libyan, Spanish and Tunisian olive oil production in the Roman empire. *Journal of Roman Archaeology*, 1:33–56.
- Mattingly, D. (1994). Regional variation in Roman oleoculture: some problems of comparability. In Carlsen, J., Ørsted, P., and Skydsgaard, J., editors, *Landuse in the Roman Empire*, pages 91–106. Rome.
- Mattingly, D. (2007). Supplying Rome and the empire: some conclusions. In Papi, E. and Bonifay, M., editors, *Supplying Rome and the empire: the proceedings of an international seminar held at Siena-Certosa di Pontignano on May 2-4, 2004, on Rome, the provinces, production and distribution*, volume 69 of *Journal of Roman Archaeology. Supplementary Series*, pages 219–27. Portsmouth.
- Mattingly, D. (2011). *Imperialism, Power, and Identity. Experiencing the Roman Empire*. Oxford and Princeton.
- Mattingly, D. and Aldrete, G. (2000). The Feeding of Imperial Rome: The Mechanics of the Food Supply System. In Coulston, J. and Dodge, H., editors, *Ancient Rome: The Archaeology of the Eternal City*, pages 142–66. Havertown.
- Maurina, B. (1995). Trento – Palazzo Tabarelli. Le anfore. In Cavada, E., editor, *Materiali per la storia urbana di Tridentum*, ArcheoAlp - Archeologia delle Alpi, pages 209–70. Trento.
- Mazzeo Saracino, L. (1985). Terra sigillata nord-italica. In Pugliese Carratelli, G., editor, *Atlante delle forme ceramiche. II, Ceramica fine romana nel bacino mediterraneo, tardo ellenismo e primo impero*, pages 175–230. Rome.
- Mazzeo Saracino, L. (2000). Lo studio delle terre sigillate padane: problemi e prospettive. In Brogliolo, G. and Olcese, G., editors, *Produzione ceramica in area padana tra il II secolo a.C. e il VII secolo d.C: nuovi dati e prospettive di ricerca: convegno internazionale, Desenzano del Garda, 8-10 aprile 1999*, pages 31–43. Mantua.
- Mazzeo Saracino, L. (2005). *Il complesso edilizio di età romana nell'area dell'ex*

- Vescovado a Rimini*. Florence.
- Mazzocchin, S. (2009). Le Anfore con Collo ad Imbuto: Nuovi Dati e Prospettive di Ricerca. In Pesavento Mattioli, S. and Carre, M. B., editors, *Olio e pesce in epoca romana: produzione e commercio nelle regioni dell'Alto Adriatico: atti del convegno (Padova 16 febbraio 2007)*, pages 191–213. Rome.
- Mazzocchin, S. (2011). *Traffici commerciali a Vicenza in epoca romana: i dati delle anfore*. Thesis.
- Mazzocchin, S. and Furlan, G. (2016). A peculiar Roman context in Vicenza. A new approach on Pottery and Amphorae. *Rei Cretariæ Romanæ Fautorvm*, 44:221–28.
- Mazzocchin, S. and Wilkins, B. (2013). Fish and Crustaceans from a Roman Amphora in Northern Italy. *Archaeofauna*, 22:105–11.
- McCallum, M. (2004). *Tiberis Navigabilis: Commercial Activity Between Rome and the Middle Tiber Basin During the Roman Period*. Thesis.
- McCormick, M. (2001). *Origins of the European Economy: Communications and Commerce AD 300 – 900*. Cambridge.
- McCormick, M., Büntgen, U., Cane, M., Cook, E., Harper, K., Huybers, P., Litt, T., Manning, S. W., Mayewski, P., More, A., Nicolussi, K., and Tegel, W. (2012). Climate Change during and after the Roman Empire: Reconstructing the Past from Scientific and Historical Evidence. *Journal of Interdisciplinary History*, 43(2):169–220.
- Medas, S. (2003a). L'archeologia fluviale del medio corso del Po. Attualità e prospettive. In Bacchi, N., editor, *L'Anima del Po. Terre, acque e uomini tra Enza e Oglio*, pages 159–83. Parma.
- Medas, S. (2003b). The Late-Roman "Parco di Teodorico" Wreck, Ravenna, Italy: Preliminary Remarks on the Hull and the Shipbuilding. In Beltrame, C., editor, *Boats, Ships, and Shipyards. Proceedings of the Ninth International Symposium on Boat and Ship Archaeology Venice 2000*, pages 42–48. Venezia.
- Medas, S. (2018). La Navigazione Lungo le Idrovie Padane in Epoca Romana. In Cantoni, G. and Capurso, A., editors, *On the Road. Via Emilia 187 A.C. - 2017*, pages 146–161. Parma.
- Meeks, E. (2015). The design and implementation of ORBIS: The Stanford geospatial network model of the Roman world. *Bulletin of the Association for Information Science and Technology*, 41(2):17–21.
- Mees, A. (2011). *Die Verbreitung von Terra Sigillata aus den Manufakturen von Arezzo, Pisa, Lyon und La Graufesenque: die Transformation der italischen Sigillata-Herstellung in Gallien*. Mainz.
- Mees, A. and Polak, M. (2013). Scattered pots. Exploring spatial and chronological aspects of Samian Ware. In Fulford, M. and Durham, E., editors, *Seeing*

- Red: new economic and social perspectives on terra sigillata*, pages 36–48. London.
- Meiggs, R. (1982). *Trees and timber in the ancient Mediterranean world*. Oxford.
- Melli, P. (2004). The role of Genoa in Mediterranean trade in Antiquity. In Pasquinucci, M. and Weski, T., editors, *Close Encounters: Sea and Riverborne Trade, Ports and Hinterlands, Ship Construction and Navigation in Antiquity, the Middle Ages and in Modern Time*, BAR International Series. Oxford.
- Melli, P. and Pasquinucci, M. (1998). Prospettive di ricerca a Genova e nel suo territorio. In Sena Chiesa, G. and Arslan, A., editors, *Optima via. Postumia. Storia e archeologia di una grande strada romana alle radici dell'Europa*, pages 417–33. Cremona.
- Menchelli, S. (2005). La terra sigillata. In Gandolfi, D., editor, *La ceramica e i materiali di età romana. Classi, produzioni, commerci e consumi*, page 155–68. Bordighera.
- Menchelli, S. and Sangriso, P. (2017). Pisan sigillata: Augustan ideology with a few images. In Flecker, M., editor, *Neue Bildwelten zu Ikonographie und Hermeneutik italischer Sigillata*, pages 53–71. Rahden and Leidorf.
- Mercando, L. (1972). Recenti rinvenimenti nelle Marche di terra sigillata nord-italica. In Bovini, G. and Mansuelli, G., editors, *I problemi della ceramica romana di Ravenna, della Valle Padana e dell'alto Adriatico. Atti del Convegno Internazionale Ravenna, 10 - 12 Maggio 1969*, pages 203–20. Bologna.
- Mertens, J. (1972). Terre sigillée d'Ordon. *Ordon*, 6:221–40.
- Michelini, P. and Mazzocchin, S. (1998). Este: la temporanea bonifica ad uso funerario di un spazio lungo il fiume. In Pesavento Mattioli, S., editor, *Bonifiche e drenaggi con anfore in epoca romana: aspetti tecnici e topografici. Atti del seminario di studi di Padova 19–20 ottobre 1995*, page 223–35. Modena.
- Middleton, P. (1980). La Graufesenque: a question of marketing. *Athenaeum*, 58:186–92.
- Millar, F. (1995). The last century of the Republic: Whose history? *Journal of Roman Studies*, 85:236–43.
- Mills, B. (2017). Social Network Analysis in Archaeology. *Annual Review of Anthropology*, 46(1):379–397.
- Minato, G. (2018). Marmi. In Sperti, L., Tirelli, M., and Cipriano, S., editors, *Prima dello scavo. Il survey 2012 ad Altino*, pages 191–99. Venice.
- Mirabella Roberti, M. (1961). Archeologia ed arte di Brescia romana. In Trecani degli Alfieri, G., editor, *Storia di Brescia, I*, pages 278–80. Brescia.
- Modrzejewska, I. and Pianetti, F. (1994). Anfore spagnole del deposito di Verona (Italia). Interpretazione dei dati analitici. *Archivo español de arqueología*, 67:147–55.

- Mollo Mezzana, R. (1992). La strada romana in Valle d'Aosta: procedimenti tecnici e costruttivi. *Atlante tematico di topografia antica*, 1:58–72.
- Mongardi, M. (2014). *L'instrumentum fittile inscriptum della colonia romana di Mutina e del suo territorio*. Thesis.
- Montalcini De Angelis D'Ossat, M. (1993). Como: rilettura di una città. In *Novum Comum 2050, Atti del Convegno celebrativo della fondazione di Como romana (Como, Camera di commercio, 8-9 novembre 1991)*, pages 53–57. Como.
- Montanari, A. (2012). Hydrology of the Po River: looking for changing patterns in river discharge. *Hydrology and Earth System Sciences*, 16:3739–47.
- Moore, C. and Jackson, J. (1925). *The Histories. Vol. 1. Books I-III*. Loeb Classical Library. Cambridge (MA).
- Morandini, F. (2000). Produzioni ceramiche di media età imperiale a Verona. Impianti produttivi e scarichi da vecchi ritrovamenti e recenti indagini. In Brogiolo, G., editor, *Produzione ceramica in area padana tra il II secolo a.c. e il VII secolo d.c.: nuovi dati e prospettive di ricerca. Convegno internazionale di Desenzano del Garda, 8-10 aprile 1999*, pages 165–73. Mantua.
- Morandini, F. (2008a). La Ceramica Importazione Africana. In Cavalieri Manasse, G., editor, *L'area del Capitolium di Verona: ricerche storiche e archeologiche.*, pages 405–16. Verona.
- Morandini, F. (2008b). Le ceramiche fini e le terre sigillate di produzione non africana. In Cavalieri Manasse, G., editor, *L'area del Capitolium di Verona: ricerche storiche e archeologiche.*, pages 330–42. Verona.
- Morel, J.-P. (1981). *Céramique campanienne. Les formes*. Rome.
- Morillo, A., Fernández Ochoa, C., and Salido Dominguez, J. (2016). Hispania and the Atlantic Route in Roman Times: new Approaches to Ports and Trade. *Oxford Journal of Archaeology*, 35(3):267–284.
- Morisani, S. (2014). Terra sigillata italica. In Mazzeo Saracino, L., editor, *Scavi di Suasa I. I reperti ceramici e vitrei dalla Domus dei Coiedii*, pages 161–212. Bologna.
- Morley, N. (2007). *Trade in Classical Antiquity*. Cambridge.
- Morley, N. (2012). A Forum on Trade. In Scheidel, W., editor, *The Cambridge Companion to the Roman Economy*, pages 309–14. Cambridge.
- Morris, I., Saller, R., and Scheidel, W. (2007a). *Cambridge economic history of the Greco-Roman world*. Cambridge.
- Morris, I., Saller, R., and Scheidel, W. (2007b). Introduction. In Scheidel, W., Morris, I., and Saller, R., editors, *The Cambridge Economic History of the Greco-Roman World*, pages 1–12. Cambridge.
- Mosca, A. (2015). Marble and stones used in the central Eastern Alpine area

- and in the Northern area of Benacus: topographical reconstruction of trade routes and aspects of use in the Roman era. In Pensabene, P. and Gasparini, E., editors, *ASMOSIA X: proceedings of the tenth International Conference of ASMOSIA, Association for the Study of Marble Other Stones in Antiquity, Rome, 21-26 May 2012*, pages 575–84. Rome.
- Mozzi, P., Fontana, A., Ferrarese, F., Ninfo, A., Campana, S., and Francese, R. (2016). The Roman City of Altinum, Venice Lagoon, from Remote Sensing and Geophysical Prospection. *Archaeological Prospection*, 23:27–44.
- Mozzi, P., Piovan, S., and Corrà, E. (2020). Long-term drivers and impacts of abrupt river changes in managed lowlands of the Adige River and northern Po delta (Northern Italy). *Quaternary international*, 538:80–93.
- Mozzi, P., Piovan, S., Mossato, S., Cucato, M., Abba, T., and Fontana, A. (2010). Palaeohydrography and early settlements in Padua (Italy). *Italian Journal of Quaternary Sciences*, 23:387–400.
- Muzzoli, M. (2010). Le ricerche sui resti della centuriazione cinquant’anni dopo. *Atlante tematico di topografia antica*, 20:7–49.
- Mócsy, A. (1974). *Pannonia and Upper Moesia: A History of the Middle Danube Provinces of the Roman Empire*. London.
- Nelson, B. (1970). Hydrography, Sediment Dispersal, and Recent Historical Development of the Po River Delta, Italy. *Deltaic Sedimentation, Modern and Ancient*, 15:152–84.
- Nieto, F. J., Puig, A., Palau, H., and Nieto, P. (1989). *Excavacions arqueològiques subaquàtiques a Cala Culip*, volume 1 of *Sèrie monogràfica (Centre d’Investigacions Arqueològiques de Girona)*. Girona.
- Ninfo, A., Ciavola, P., and Billi, P. (2018). The Po Delta is restarting progradation: geomorphological evolution based on a 47-years Earth Observation dataset. *Nature. Scientific Reports*, 8:1–6.
- Nobile De Agostini, I. (2005). *Indagini archeologiche a Como. Lo scavo nei pressi della Porta Pretoria*. Como.
- Oberosler, R. (1995). Trento - Palazzo Tabarelli. Ceramiche in terra sigillata. In Cavada, E., editor, *Materiali per la storia urbana di Tridentum*, ArcheoAlp - Archeologia delle Alpi, pages 271–357. Trento.
- Okabe, A. and Sugihara, K. (2012). *Spatial analysis along networks: statistical and computational methods*. Statistics in practice. Hoboken, N.J.
- Olcese, G. (1998). Ceramiche in Lombardia. In Olcese, G., editor, *Ceramiche in Lombardia tra II secolo a.C. e VII secolo d.C.: Raccolta dei dati editi*, pages 7–19. Mantua.
- Olcese, G. (1999). Le ceramiche fini del periodo II e alcuni problemi aperti nell’ambito della produzione ceramica di area padana. In Brogliolo, G., editor,

- S. Giulia di Brescia. Gli scavi dal 1980 al 1992: reperti preromani, romani e alto medievali*, pages 97–100. Florence.
- Orengo, H. and Livarda, A. (2016). The seeds of commerce: A network analysis-based approach to the Romano-British transport system. *Journal of Archaeological Science*, 66:21–35.
- Ortalli, J. (1992). La Cispadana Orientale: Via Emilia e altre Strade. *Atlante tematico di topografia antica*, 1:147–60.
- Ortalli, J. (1993). Piazza Azzarita. *Archeologia dell'Emilia-Romagna*, 1:46–48.
- Ortalli, J. (1995). Bonifiche e regolamentazioni idriche nella pianura emiliana tra l'età del ferro e la tarda antichità. *Atlante tematico di topografia antica*, 4.
- Ortalli, J., Baldoni, D., and Curina, R. (1986). *Il teatro romano di Bologna*. Bologna.
- Orton, C. (2009). 'Four pots good, two pots bad': exploring the limits of quantification in the study of archaeological ceramics. *Facta*, 3:65–74.
- Oxé, A., Comfort, H., and Kenrick, P. M. (2000). *Corpus Vasorum Arretinorum: a catalogue of the signatures, shapes and chronology of Italian sigillata*. Bonn, second edition.
- Paccolat, O., Cusanelli-Bressenel, L., and Joris, C. (2008). Le mobilier céramique du Grand Saint-Bernard (Plan de Jupiter, Plan de Brasson et Musée de l'Hospice). In Apollonia, L., editor, *Alpis Poenina. Grand Saint-Bernard: une voie à travers l'Europe: Séminaire de clôture 11-12 avril 2008, Fort de Bard (Vallée d'Aoste)*, pages 139–206. Aosta.
- Paci, G. (2009). Monumento funerario di un bottaio da Cupra Marittima. In Marengio, C., editor, *Palaia Philia. Studi di topografia antica in onore di Giovanni Uggeri*, page 289–94. Galatina.
- Page, J. (2021). Riverbed, banks and beyond: an examination of Roman infrastructure and interventions in response to hydrological risk in the Po–Venetian plain. *Papers of the British School at Rome*, FirstView:1–30.
- Pagen, M. (2018). Terra sigillata africana. In Sperti, L., Tirelli, M., and Cipriano, S., editors, *Prima dello scavo. Il survey 2012 ad Altino*, pages 82–104. Venice.
- Pagliani, M.-L. (1991). *Piacenza: forma e urbanistica*. Rome.
- Panella, C. (2002). Le anfore di età imperiale nel Mediterraneo Occidentale. *Céramiques hellénistiques et romaines 3. Publications du Centre Camille-Julien*, 28:177–275.
- Panella, C. and Tchernia, A. (1994). Produits agricoles transportés en amphores: L'Huile et surtout le vin. *L'Italie d'Auguste à Dioclétien*, 198:145–65.
- Panero, E. (2013). Vercelli, via Pastrengo. Strutture pertinenti a una banchina romana? *Quaderni della Soprintendenza Archeologica del Piemonte*, 28:311–13.

- Pantò, G. and Occelli, F. (2009). Moncalieri, frazione Testona, parco di Villa Lancia. Abitato e necropoli di età longobarda. *Quaderni della Soprintendenza Archeologica del Piemonte*, 24:227–31.
- Papaioannou, T. (2011). A reconstruction of the maritime trade patterns originating from western Asia Minor during Late Antiquity, on the basis of ceramic evidence. In Wilson, A. I. and Robinson, D., editors, *Maritime Archaeology and Ancient Trade in the Mediterranean*, pages 197–210. Oxford.
- Papisca, C. (2010). Via Annia: Adria, Padova, Altino, Concordia, Aquileia: progetto di recupero e valorizzazione di un'antica strada romana. In Veronese, F., editor, *Tra fiumi e paludi. Dal Livenza ad Altino*, pages 61–72. Padua.
- Parker, A. J. (1992). *Ancient shipwrecks of the Mediterranean the Roman provinces*. Oxford.
- Parodi, A. (2013). *Le anfore di età romana (I sec a.C – V d.C-) dall'insediamento alla foce del torrente Prino, Imperia-Porto Maurizio*. Thesis.
- Passi Pitcher, L. (1996). *Bedriacum: ricerche archeologiche a Calvatone*, volume 2. Milan.
- Paton, W. (2010). *Polybius. The Histories. Vol. 1. Books 1-2*. Loeb Classical Library. Cambridge (MA).
- Patterson, H. (2004). *Bridging the Tiber: Approaches to Regional Archaeology in the Tiber Valley*. London.
- Patterson, H., Di Giuseppe, H., and Witcher, R. (2020). *Changing Landscapes of the Middle Tiber Valley*. Archaeological Monographs of the British School at Rome. Rome and London.
- Patterson, H. and Lapadula, E. (1997). Le anfore di Spello nelle Regiones VI e VII. *Papers of the British School at Rome*, 65:127–56.
- Patterson, J. (2006). *Landscapes and Cities: Rural Settlement and Civic Transformation in Early Imperial Italy*. Oxford.
- Pavoni, M. (2008). Le anfore italiche egee e ispaniche di età tardo repubblicana e di prima età imperiale. In Cavalieri Manasse, G., editor, *L'area del Capitolium di Verona: ricerche storiche e archeologiche*, pages 369–71. Verona.
- Peacock, D. and Maxfield, V. (1997). *Survey and Excavation—Mons Claudianus, 1987–1993. Volume I: Topography Quarries*. Fouilles de l'Institut Français d'Archéologie Orientale. Cairo.
- Pecci, A., Clarke, J., Thomas, M., Muslinc, J., van der Graaff, I., Toniolo, L., Miriello, D., Crisci, G., Buonincontri, m., and Di Pasquale, G. (2017). Use and reuse of amphorae. Wine residues in Dressel 2–4 amphorae from Oplontis Villa B (Torre Annunziata, Italy). *Journal of Archaeological Science*, 12:515–521.
- Pegoretti, G. (1869). *Manuale pratico per l'estimazione dei lavori architettonici stradali, idraulici e di fortificazione per uso degli ingegneri ed architetti*, vol-

- ume 1. Milan.
- Pellegrini, G. (2004). *Item ab Aquileia Bononiam: un itinerario di età romana tra la via Emilia ed il Po. Atlante tematico di topografia antica*, 13:43–63.
- Pellegrini, L. and Vercesi, P. (2017). Landscapes and Landforms Driven by Geological Structures in the Northwestern Apennines. In Soldati, M. and Marchetti, M., editors, *Landscapes and Landforms of Italy*, pages 203–213. Cham.
- Pellegrini, S., Vicari, D., Bagni, D., and Covizzi, C. (1996). Reggio Emilia, area della palestra dell’Istituto “Scaruffi”. In Ambrosetti, G., Macellari, R., and Malnati, L., editors, *Lepidoregio. Testimonianze di età romana a Reggio Emilia*, pages 187–215. Reggio Emilia.
- Pensabene, P. (2002). Il fenomeno del marmo nel mondo romano. In De Nuccio, M. and Ungaro, L., editors, *I marmi colorati della Roma imperiale*, pages 3–68. Padua.
- Pensabene, P. (2015). Blocks and quarry marks in the Museum of Aquileia. In Pensabene, P. and Gasparini, E., editors, *ASMOSIA X: proceedings of the tenth International Conference of ASMOSIA, Association for the Study of Marble Other Stones in Antiquity, Rome, 21-26 May 2012*, pages 611–14. Rome.
- Perry, J. (2016). Sub-Elites. In Cooley, A., editor, *A companion to Roman Italy*, pages 498–512. Oxford.
- Pesavento Mattioli, S. (1992). *Anfore romane a Padova: ritrovamenti dalla città*. Modena.
- Pesavento Mattioli, S. (1998). *Bonifiche e drenaggi con anfore in epoca romana: aspetti tecnici e topografici. Atti del seminario di studi di Padova 19–20 ottobre 1995*. Modena.
- Peyre, C. (1979). *La Cisalpine Gauloise du III au I siècle avant J.-C.* Paris.
- Peña, J. (1989). P.Giss.69: evidence for the supplying of stone transport operations in Roman Egypt and the production of fifty-foot monolithic column shafts. *Journal of Roman Archaeology*, 2:126–32.
- Peña, J. (2007a). The quantitative analysis of Roman pottery: general problems, the methods employed at the Palatine East, and the supply of African Sigillata to Rome. In Papi, E. and Bonifay, M., editors, *Supplying Rome and the Empire: The Proceedings of an International Seminar Held at Siena-Certosa Di Pontignano on May 2-4, 2004, on Rome, the Provinces, Production and Distribution*, volume 69 of *Journal of Roman Archaeology supplementary monographs*, pages 151–72. Portsmouth.
- Peña, J. (2007b). *Roman Pottery in the Archaeological Record*. New York.
- Picco, L., Rainato, R., Mao, L., Delai, F., Tonon, A., Ravazzolo, D., and Lenzi, M. A. (2013). Characterization of fluvial islands along three different gravel-bed rivers of North-Eastern Italy. *Journal of Agricultural Engineering (Pisa)*,

- Italy*), 44(2s).
- Picon, M. (2002). À propos des sigillées, présigillées et imitations de sigillées: Questions de “coûts” et de marché. In SFECAG, editor, *Société française d'étude de la céramique antique en Gaule, Actes du congrès de Bayeux 2002*, pages 345–56. Marsailles.
- Picon, M. and Lasfargues, J. (1974). Transfert de moules entre les ateliers d'Arezzo et ceux de Lyon. *Revue archéologique de l'Est et du Centre-Est*, 25:60–69.
- Piovan, S., Peretto, R., and Mozzi, P. (2006). Palaeohydrography and ancient settlements in the Adige River plain, between Rovigo and Adria (Italy). In Campana, S. and Forte, M., editors, *From Space to Place: 2nd International Conference on Remote Sensing in Archaeology: Proceedings of the 2nd International Workshop, CNR, Rome, Italy, December 4-7, 2006*, pages 311–19. Oxford.
- Pisano Briani, A. (2016). Terra Sigillata. *Rivista archeologia dell'antica provincia e diocesi di Como*, 198:9–51.
- Pitts, M. (2013). Pots and comparative history. The case of imported Roman finewares and Chinese porcelain in NW Europe. In Fulford, M. and Durham, E., editors, *Seeing Red. New economic and social perspectives on Gallo-Roman terra sigillata*, pages 381–90. London.
- Pitts, M. (2015). Globalisation, Circulation, and Mass Consumption in the Roman World. In Pitts, M. and Versluys, J., editors, *Globalisation and the Roman world: world history, connectivity and material culture*, pages 69–98. Cambridge.
- Pitts, M. (2017). Gallo-Belgic wares. Objects in motion in the early Roman north-west. In Van Oyen, A. and Pitts, M., editors, *Materialising Roman Histories*, pages 47–64. Oxford and Philadelphia.
- Pizzolato, D. (2018a). Anfore africane. In Sperti, L., Tirelli, M., and Cipriano, S., editors, *Prima dello scavo. Il survey 2012 ad Altino*, pages 154–66. Venice.
- Pizzolato, D. (2018b). Anfore iberiche. In Sperti, L., Tirelli, M., and Cipriano, S., editors, *Prima dello scavo. Il survey 2012 ad Altino*, pages 167–73. Venice.
- Po River Basin Authority, T. (2006). Caratteristiche del bacino del fiume Po e primo esame dell'impatto ambientale delle attività umane sulle risorse idriche. Report.
- Poblome, J. and Waelkens, M. (2003). Sagalassos and Alexandria. Exchange in the Eastern Mediterranean. *Publications de l'Institut Français d'Études Anatoliennes*, 15(1):179–191.
- Poblome, J., Özden Gerçeker, S., and Loopmans, M. (2017). Different similarities or similar differences? Thoughts on koine, oligopoly and regionalism. In

- Van Oyen, A. and Pitts, M., editors, *Materialising Roman Histories*, pages 85–100. Oxford and Philadelphia.
- Poletti Ecclesia, E. (2019). Ricognizione sui più antichi manufatti in marmo di Candoglia ed elementi per l'individuazione della lavorazione lapidaria sul lago Maggiore nel I secolo d.C. In Mergozzo, G. A. e. M. d., editor, *Le Vie della pietra: estrazione e diffusione delle pietre da opera alpine dall'età romana all'età moderna. Atti del Convegno in occasione del decennale dell'Ecomuseo del Granito di Montorfano (28-29 Ottobre 2017)*, pages 41–70. Mergozzo.
- Ponsich, M. (1974). *Implantation rurale antique sur le Bas-Guadalquivir*, volume I of *Publications de la Casa de Velázquez. Série Archéologie*. Madrid.
- Ponsich, M. (1979). *Implantation rurale antique sur le Bas-Guadalquivir*, volume II of *Publications de la Casa de Velázquez. Série Archéologie*. Madrid.
- Porteous, J. D. (1977). *Canal ports: the urban achievement of the canal age*. London.
- Preacco, M. (2014). *Augusta Bagiennorum. Storia e archeologia di una città augustea*. Turin.
- Preiser-Kapeller, J. and Werther, L. (2018). Connecting Harbours. A comparison of traffic networks across ancient and medieval Europe. In von Carnap-Bornheim, C., Daim, F., Ettel, P., and Warnke, U., editors, *Harbours as Objects of Interdisciplinary Research: Archaeology + History + Geosciences, Interdisziplinäre Forschungen zu Häfen von der Römischen Kaiserzeit bis zum Mittelalter*, pages 7–31.
- Prenc, F. (2002). *Le pianificazioni agrarie di età romana nella pianura aquileiese*. Trieste.
- Previato, C. (2018). Aurisina Limestone in the Roman Age: from Karst Quarries to the Cities of the Adriatic Basin. In Matetić Poljak, D. and Marasović, K., editors, *ASMOSIA XI, Interdisciplinary Studies on Ancient Stone. Proceedings of the XI ASMOSIA Conference, Split 2015*, pages 933–39. Split.
- Previato, C. and Mareso, N. (2015). Marbles from the *Domus* of 'Bestie ferite' and from the *Domus* of 'Tito Macro' in Aquileia (UD), Italy. In Pensabene, P. and Gasparini, E., editors, *Interdisciplinary Studies on Ancient Stone. ASMOSIA X. Proceedings of the Tenth International Conference of ASMOSIA Association for the Study of Marble Other Stones in Antiquity. Rome, 21-26 May 2012*, pages 299–309. Rome.
- Previato, C. and Zara, A. (2014). Il Trasporto della Pietradi Vicenza in Età Romana. Il Relitto del Fiume Bacchiglione. *Marmora*, 10:59–78.
- Previato, C. and Zara, A. (2018). Quarrying, circulation and use of stone during the Roman Age. A Database and GIS project about *Regio X - Venetia et Histria*. The case study of the Euganean Trachyte. In Matetić Poljak, D. and

- Marasović, K., editors, *ASMOSIA XI, Interdisciplinary Studies on Ancient Stone. Proceedings of the XI ASMOSIA Conference, Split 2015*, volume 11, pages 597–609. Split.
- Profumo, M. (2005). Fronte di sarcofago detta “sarcofago del vinaio”. In De Marinis, G., editor, *Arte romana nei musei delle Marche*, pages 266–67. Rome.
- Purcell, N. (1990). The Creation of Provincial Landscape: The Roman Impact on Cisalpine Gaul. In Blagg, T. and Millett, M., editors, *The Early Roman Empire in the West*, pages 7–29. Oxford.
- Purcell, N. (2012). Rivers and the geography of power. *Pallas*, 90:373–87.
- Quercia, A., Semeraro, M., and Barello, F. (2015). Strevi, località Cascina Braida. Un insediamento rurale di età romana. *Quaderni della Soprintendenza Archeologica del Piemonte*, 30:143–72.
- Quilici, L. (2009). Land Transport, Part 1: Roads and Bridges. In Oleson, J., editor, *The Oxford Handbook of Engineering and Technology in the Classical World*, pages 551–79. Oxford.
- Quiri, E. (2009). Importazioni di anfore altoadriatiche a Torino. In Pesavento Mattioli, S. and Carre, M., editors, *Olio e pesce in epoca romana. Produzione e commercio nelle regioni dell’Alto Adriatico, Atti del Convegno (Padova, 16 febbraio 2007)*, pages 293–300. Padua.
- Quiri, E. (2014). Le Anfore. In Preacco, M., editor, *Augusta Bagiennorum: storia e archeologia di una città augustea*, pages 201–11. Turin.
- Quiri, E. (2015). Imports of eastern transport amphorae to Turin (Italy). In Demesticha, S., editor, *Per Terram, Per Mare: Seaborne Trade and the Distribution of Roman Amphorae in the Mediterranean*, pages 161–80. Uppsala.
- Quiri, E. and Spagnolo Garzoli, G. (2015). Imports of alum from Milos to Novara (Italy). In Demesticha, S., editor, *Per Terram, Per Mare: Seaborne Trade and the Distribution of Roman Amphorae in the Mediterranean*, pages 181–88. Uppsala.
- Rackham, H. (1942). *Pliny. Natural History. Vol. 2. Books 3–7*. Loeb Classical Library. Cambridge (MA).
- Radbauer, S. (2013). The Roman terra sigillata production of Westerndorf (South Bavaria, Germany): history, location and technology. In Fulford, M. and Durham, E., editors, *Seeing Red: New Economic and Social Perspectives on Terra Sigillata*, pages 151–64. London.
- Raepsaet, G. (2009). Land Transport, Part 2: Riding, Harnesses, and Vehicles. In Oleson, J., editor, *The Oxford Handbook of Engineering and Technology in the Classical World*, pages 580–605.
- Ratto, S. (2014). Il vasellame ceramico da mensa e da cucina: vita quotidiana e indicatori commerciali. In Preacco, M., editor, *Augusta Bagiennorum. Storia*

- e archeologia di una città augustea*, pages 157–200. Turin.
- Ratto, S. and Crivello, A. (2014). Un insediamento rustico di età romana a San Giorgio Canavese. *Quaderni della Soprintendenza Archeologica del Piemonte*, 29:19–26.
- Ravasi, T. and Barbaglio, F. (2008). Merci e Persone sui Fiumi. Le imbarcazioni monossili conservate presso il Museo Civico di Crema e del Cremasco. In Baioni, M. and Fredella, C., editors, *Archaeotrade. Antichi Commerci in Lombardia Orientale*, pages 37–61. Milan.
- Reinhart, A. (2015). *Statistics Done Wrong: The Woefully Complete Guide*. San Francisco.
- Remesal-Rodríguez, J. (1980). Reflejos económicos y sociales en la producción de ánforas olearias béticas (Dressel 20). In Blázquez Martín, J., editor, *Producción y comercio del aceite en la antigüedad. Primer congreso internacional. Universidad Complutense, Madrid.*, page 131–53. Madrid.
- Remesal-Rodríguez, J. (1986). *La annona militaris y la exportacion de aceite bético a Germania: Con un corpus de sellos en ánforas Dressel, 20 hallados en Nimega, Colonia, Mainz, Saalburg, Zugmantel y Nida-Heddernheim*. Madrid.
- Remesal-Rodríguez, J. (1997). *Heeresversorgung und die wirtschaftlichen Beziehungen zwischen der Baetica und Germanien: Materialien zu einem Corpus der in Deutschland veröffentlichten Stempel auf Amphoren der Form Dressel 20*. Stuttgart.
- Remesal-Rodríguez, J. (1998). Baetican olive oil and the Roman economy. In Keay, S., editor, *The Archaeology of early Roman Baetica*, pages 183–99. Portsmouth.
- Remesal-Rodríguez, J. (2002). Baetica and Germania. Notes on the concept of provincial interdependence in the Roman Empire. In Erdkamp, P., editor, *The Roman Army and the Economy*, pages 293–308.
- Remesal Rodríguez, J. and Revilla Calvo, V. (1991). Weinamphoren aus Hispania citerior und Gallia narbonensis in Deutschland und Holland. *Fundberichte Baden-Württemberg*, 16:349–89.
- Reynolds, J. (1995). *Trade in the Western Mediterranean, AD 400–700: the Ceramic Evidence*. BAR International Series. Oxford.
- Rice, C. (2012). *Port Economies and Maritime Trade in the Roman Mediterranean: 166 BC to AD 300*. Thesis.
- Rice, C. (2016). Shipwreck cargoes in the western Mediterranean and the organization of Roman maritime trade. *Journal of Roman Archaeology*, 29:165–92.
- Rickman, G. (1971). *Roman granaries and store buildings*. London.
- Rieth, E. (1998). *Des bateaux et des fleuves. Archéologie de la batellerie du néolithique aux temps modernes en France*. Paris.

- Rieth, E. (2014). Le chaland Arles-Rhône 3 dans la batellerie gallo-romaine : étude typologique et interprétation historique. *Archaeonautica*, 18:279–87.
- Rieth, E. and Guyon, M. (2011). Les chalands gallo-romains du Parc Saint-Georges. In Boetto, G., Pomey, P., and Tchernia, A., editors, *Batellerie gallo-romaine: Pratiques régionales et influences maritimes méditerranéennes*. Aix-en-Provence.
- Rigato, D. and Mongardi, M. (2017). L’instrumentum inscriptum. In Labate, D. and Malnati, L., editors, *Parco Novi Sad di Modena: dallo scavo al parco archeologico. Archeologia, antropologia, storia e ambiente di un insediamento periurbano di età romana e medievale*, pages 93–115. Florence.
- Righini, V. (2004). Fra produttori e consumatori: I materiali fittili pesanti nella Cisalpina. In Santoro, S., editor, *Artigianato e produzione nella Cisalpina: Parte I. Proposte di metodo e prime applicazioni*, pages 239–64. Florence.
- Robino, M. (2008). La ceramica fine da mensa: vernice nera, terra sigillata, pareti sottili. In Bacchetta, A. and Venturino Gambari, M., editors, *Raccolta archeologica di Augusto Scovazzi*, pages 21–34. Genoa.
- Robino, M. (2017). Le ceramiche fini da mensa, le ceramiche comuni e le lucerne. In Bacchetta, A. and Venturino Gambari, M., editors, *La città ritrovata. Il Foro di Aquae Statiellae e il suo quartiere*, pages 61–106. Acqui Terme.
- Robinson, D. (2020). Maritime Networks in the Ancient Mediterranean World. *The International Journal of Nautical Archaeology*, 49(1):207–08.
- Robinson, D. and Wilson, A. (2011). *Maritime archaeology and ancient trade in the Mediterranean*. Oxford Centre for Maritime Archaeology Monograph. Oxford.
- Rodrigue, J.-P. and Notteboom, T. (2020). Transportation, Economy and Society. In Rodrigue, J.-P., editor, *The Geography of Transport Systems*, pages 90–123. London, fifth edition.
- Roffia, E. (1991). Ceramica Africana. In Caporusso, D., editor, *Scavi MM3. Ricerche di archeologia urbana a Milano durante la costruzione della linea 3*, pages 89–105. Milan.
- Romanowska, I., Brughmans, T., Bes, P., Carrignon, S., Egelund, L., Lichtenberger, A., and Raja, R. (2021). A Study of the Centuries-Long Reliance on Local Ceramics in Jerash Through Full Quantification and Simulation. *Journal of Archaeological Method and Theory*, pages 1–19.
- Romer, F. (1998). *Pomponius Mela’s Description of the World*. Michigan.
- Roncaglia, C. (2013). Client Prefects?: Rome and the Cottians in the Western Alps. *Phoenix*, 67(3):353–372.
- Roncaglia, C. (2018). *Northern Italy in the Roman World: From the Bronze Age to Late Antiquity*. Baltimore.

- Roncuzzi, A. (1992). Topografia di Ravenna antica: le mura. *Corsi di cultura sull'arte ravennate e bizantina*, 39:691–741.
- Roncuzzi, A. and Veggi, L. (1967). Risultati di una ricerca dell'antica topografia nel territorio a Nord di Ravenna. *Bollettino Economico della Camera di Ravenna*, 2:287–92.
- Roncuzzi, A. and Veggi, L. (1968). Nuovi studi sull'antica topografia ravennate. *Bollettino Economico della Camera di Ravenna*, 3:193–201.
- Rosada, G. and Bonetto, J. (1995). L'Arzeron della Regina: assetto territorial e sistema idraulicoviaro a nord ovest di Padova. *Atlante tematico di topografia antica*, 4:17–36.
- Rossi, C. (2013). *Le necropoli urbane di Padova romane*. Thesis.
- Rossi, F. (2002). *Nuove ricerche sul Capitolium di Brescia: scavi, studi e restauri*. Milan.
- Rossi, F. (2014). *Un luogo per gli dei: l'area del Capitolium a Brescia*. Florence.
- Rostovtzeff, M. (1926). *The Social and Economic History of the Roman Empire*. Oxford.
- Rousse, C. (2007). L'évolution des importations à Aquilée. IV. Les productions africaines. *Antichità Altoadriatiche*, 65:605–20.
- Rousse, C. (2013). Opérations de canalisation dans les ports fluvio-maritimes de la *Regio X Venetia Histria*: réflexions sur l'urbanisme et les transformations du territoire à l'époque Romaine. *Antichità Altoadriatiche*, 76:123–40.
- Rubio-Campillo, X., Coto-Sarmiento, M., Pérez-González, J., and Remesal Rodríguez, J. (2017). Bayesian analysis and free market trade within the Roman Empire. *Antiquity*, 91:1241–1252.
- Rubio-Campillo, X., Montanierb, J., Rullc, G., Lorenzod, J., Díaz, J., Pérez-González, J., and Remesal Rodríguez, J. (2018). The ecology of Roman trade. Reconstructing provincial connectivity with similarity measures. *Journal of Archaeological Science*, 92:37–47.
- Ruggiu Zaccaria, A. (1969). Indagini sull'insediamento longobardo a Brescia. *Contributi dell'Istituto di Archeologia*, 2:110–50.
- Rulli, E. (2008). *I marmi del teatro romano di Augusta Bagiennorum: analisi e schedatura*. Thesis.
- Russell, B. (2008). The dynamics of stone transport between the Roman Mediterranean and its hinterland. *Facta*, 2:107–26.
- Russell, B. (2011). The Roman Sarcophagus 'Industry': a Reconsideration. In Elsner, J. and Huskinson, J., editors, *Life, Death and Representation. Some New Work on Roman Sarcophagi*, Millennium-Studien/Millennium Studies, pages 119–147. Berlin and New York.
- Russell, B. (2013). *The Economics of the Roman Stone Trade*. Oxford.

- Russell, B. (2018a). ‘Difficult and costly’: Stone transport, its constraints, and its impact. In Coquelet, C., Creemers, G., Dreesen, R., and Goemare, E., editors, *Roman Ornamental Stones in North-Western Europe*, pages 131–150. Liège.
- Russell, B. (2018b). Stone Use and the Economy: Demand, Distribution, and the State. In Wilson, A. I. and Bowman, A., editors, *Trade, Commerce, and the State in the Roman World*, Oxford Studies on the Roman Economy, pages 237–64. Oxford.
- Sacchi, F., Dell’Acqua, A., Bugini, R., and Folli, L. (2011). I portici del foro di Brescia. In Maggi, S., editor, *I complessi forensi della Cisalpina romana. Nuovi dati. Atti del convegno di studi, Pavia 12.–13. marzo 2009*, pages 115–29. Borgo San Lorenzo.
- Saller, R. (2005). Framing the debate over growth in the ancient economy. In Manning, J. and Morris, I., editors, *The Ancient Economy: Evidence and Models*, pages 223–38. Stanford.
- Salmon, E. (1982). *The Making of Roman Italy*. Ithaca.
- Salomon, F., Purdue, L., Goiran, J., and Berger, J. (2014). Introduction to the special issue: Roman canals studies—main research aims. *Water History*, 6(1):1–9.
- Sanesi, L., Bonomi, S., and A., T. (1986). L’insediamento romano di Corte Cavanella di Loreo. *Quaderni di Archeologia del Veneto*, 2:25–30.
- Sanesi, L., Peretto, R., and Zerbinati, E. (1985). L’insediamento romano di Corte Cavanella (Loreo). Rapporto preliminare. *Quaderni di Archeologia del Veneto*, 1:11–23.
- Sarabia-Bautista, J. (2017). L’acqua come elemento generatore dei paesaggi storici nella pianura sud-orientale dei Colli Euganei. In Brogiolo, G., editor, *Este, l’Adige e i Colli Euganei. Storie di paesaggi*, pages 69–88. Mantua.
- Sauer, E. (2013). Milestones - misunderstood stone monuments: displays of loyalty in times of instability. *Ancient Society*, 44:1–36.
- Savage, J. (1961). *Saint Ambrose. Hexameron, Paradise, and Cain and Abel*. The Fathers Of The Church. New York.
- Scagliarini Corlàita, D. (1989). L’insediamento agrario in Emilia Romagna nell’età romana. In Adani, G., editor, *Insedimenti rurali in Emilia Romagna – Marche*, pages 11–36. Milan.
- Scheidel, W. (2009). In search of Roman economic growth. *Journal of Roman Archaeology*, 22(1):46–70.
- Scheidel, W. (2012). Approaching the Roman economy. In Scheidel, W., editor, *The Cambridge Companion to the Roman Economy*, pages 1–21. Cambridge.
- Scheidel, W. (2013). Explaining the maritime freight charges in Diocletian’s Prices Edict. *Journal of Roman Archaeology*, 26:464–468.

- Scheidel, W. (2014). The shape of the Roman world: modelling imperial connectivity. *Journal of Roman Archaeology*, 27:7–32.
- Schindler, M. and Zabezhlicky Scheffenecker, S. (1977). *Die glatte rote Terra sigillata vom Magdalensberg*. Klagenfurt.
- Schindler-Kaudelka, E. (1980). *Die römische Modelkeramik vom Magdalensberg*. Klagenfurt.
- Scott, J. (2017). *Social network analysis*. London, fourth edition.
- Secchi, L. (2017). Le anfore da trasporto. In Bachetta, A. and Venturino Gambari, M., editors, *La città ritrovata: il foro di Aquae Statiellae e il suo quartiere*, pages 107–24. Acqui Terme.
- Sena Chiesa, G., Masseroli, S., Medici, T., and Volonte, M. (1997). *Calvatone romana. Un pozzo e il suo contesto. Saggio nella zona nord dell'area di proprietà provinciale*. Milan.
- Shafie, T., Atkinson, P., Delamont, S., Cernat, A., Sakshaug, J., and Williams, R. (2020). *Social network analysis*. London.
- Sheppard, E. (2006). The economic geography project. In Bagchi-Sen, S. and Lawton Smith, H., editors, *Economic Geography. Past, present, and future*, pages 11–23. Oxon.
- Shindell, D., Schmidt, T., Miller, R., and Mann, M. (2003). Volcanic and Solar Forcing of Climate Change during the Preindustrial Era. *Journal of Climate*, 16:4094–107.
- Sigl, M., Winstrup, M., McConnell, J., Welten, K., Plunkett, G., Ludlow, F., Büntgen, U., Caffee, M., Chellman, N., Dahl-Jensen, D., Fischer, H., Kipfstuhl, S., Kostick, C., Maselli, O., Mekhaldi, F., Mulvaney, R., Muscheler, R., Pasteris, D., Pilcher, J., Salzer, M., Schüpbach, S., Steffensen, J., Vinther, B., and Woodruff, T. (2015). Timing and Climatic Forcing of Volcanic Eruptions for the Past 2500 Years. *Nature*, 523:543–62.
- Simeoni, U. and Corbau, C. (2009). A review of the Delta Po evolution (Italy) related to climatic changes and human impacts. *Geomorphology*, 107(1):64–71.
- Simey, T. (1954). *The Dock Worker*. Liverpool.
- Sindbæk, S. (2013). Broken Links and Black Boxes: Material Affiliations and Contextual Network Synthesis in the Viking World. In Knappett, C., editor, *Network Analysis in Archaeology: New Approaches to Regional Interaction*, pages 71–94. Oxford.
- Smaldino, P. and McElreath, R. (2016). The natural selection of bad science. *Royal Society Open Science*, 3(9):160384–160384.
- Smith, A. (2003). *The Political Landscape: Constellations of Authority in Early Complex Polities*. Berkley.
- Smith, A. (2007). Latium and the Latins: the hinterland of Rome. In Bradley,

- G., editor, *Ancient Italy. Regions without Boundaries*, pages 161–78. Exeter.
- Snyder, J., Dilaver, O., Stevenson, L., Mackie, J., and Smith, S. (2018). Agent-based modelling and construction – reconstructing antiquity’s largest infrastructure project. *Construction Management and Economics*, 36(6):313–27.
- Soldati, M. and Marchetti, M. (2017). *Landscapes and Landforms of Italy*. Cham.
- Spagnolo Garzoli, G., Deodato, A., Quiri, E., and Ratto, S. (2007). Genesi dei centri urbani di Vercellae e Novaria. In Brecciaroli Taborelli, L., editor, *Forme e tempi dell’urbanizzazione nella Cisalpina (II secolo a.C. – I secolo d.C.)*. *Atti delle Giornate di Studio Torino. 4-6 maggio 2006*, pages 109–26. Borgo S. Lorenzo.
- Spagnolo Garzoli, G., Deodato, A., Quiri, E., and Ratto, S. (2008). Flussi commerciali e produzioni nei municipi di Novaria e Vercellae in prima e media età imperiale. *Quaderni della Soprintendenza Archeologica del Piemonte*, (23):79–109.
- Sperti, L., Tirelli, M., and Cipriano, S. (2018). *Prima dello scavo. Il survey 2012 ad Altino*. Venice.
- Squatriti, P. (2010). The Floods of 589 and Climate Change at the Beginning of the Middle Ages: An Italian Microhistory. *Speculum*, 85:799–826.
- Starnini, E., Biagi, P., and Mazzucco, N. (2018). The beginning of the Neolithic in the Po Plain (northern Italy): Problems and perspectives. *Quaternary international*, 470:301–317.
- Stefani, M. (2017). The Po Delta Region: Depositional Evolution, Climate Change and Human Intervention Through the Last 5000 Years. In Soldati, M. and Marchetti, M., editors, *Landscapes and Landforms of Italy*, pages 193–202. Cham.
- Sternini, M. (2019). The production centres and river network of Italian terra sigillata between the Arno and Tiber valleys: a geographical point of view. *Journal of Roman Archaeology*, 32:485–94.
- Stoppioni, M. (2008). La sigillata tarda di Sarsina. In Donati, A., editor, *Storia di Sarsina I. L’età antica*, pages 713–62. Cesena.
- Surian, N. and Fontana, A. (2017). The Tagliamento River: The Fluvial Landscape and Long-Term Evolution of a Large Alpine Braided River. In Soldati, M. and Marchetti, M., editors, *Landscapes and Landforms of Italy*, pages 157–167. Cham.
- Surian, N. and Rinaldi, M. (2003). Morphological response to river engineering and management in alluvial channels in Italy. *Geomorphology*, 50:307–26.
- Talbert, R. and Bagnall, R. (2000). *The Barrington Atlas of the Greek and Roman World*. Princeton.
- Tartaron, T. (2014). *Maritime networks in the Mycenaean world*. Cambridge.

- Tassaux, F. (2004). Les Importations de l'Adriatique et de l'Italie du Nord vers les provinces danubiennes de César aux Sévères. In Urso, G., editor, *Dall'Adriatico al Danubio: L'Illirico nell'età greca e romana: Atti del convegno internazionale (Cividale di Friuli, 25–27 settembre 2003)*, pages 167–205. Pisa.
- Taylor, T. (2009). Materiality. In Bentley, R., Maschner, H., and Chippindale, C., editors, *Handbook of archaeological theories*, pages 297–320. Lanham.
- Tchernia, A. (1983). Italian wine in Gaul at the end of the republic. In Garnsey, P., Hopkins, K., and Whittaker, C., editors, *Trade in the Ancient Economy*, pages 87–104. London.
- Tchernia, A. (1986). *Le vin de l'Italie romaine. Essai d'histoire économique d'après les amphores*. Paris and Rome.
- Tchernia, A. (2011). *Les Romains et le commerce*. Naples.
- Tchernia, A. (2016). *The Romans and Trade*. Oxford.
- Tellini, C. (1994). Aspetti geomorfologici. In Zanzucchi, G., editor, *L'Appennino ligure-emiliano. Guide Regionali, Società Geologica Italiana*, page 75–80. Lodi.
- Temin, P. (2001). A Market Economy in the Early Roman Empire. *Journal of Roman Studies*, 91:169–181.
- Temin, P. (2012). The Role of Economics. In Scheidel, W., editor, *The Cambridge Companion to the Roman Economy*, pages 45–70. Cambridge.
- Temin, P. (2013). *The Roman Market Economy*. Princeton.
- Tempesta, C. (2013). Le Anfore. In Guarnieri, C., editor, *Vivere a Forum Livi. Lo scavo di via Curte a Forlì*, pages 111–24. Bologna.
- Tempesta, C. (2018). Anfore da Trasporto. In Guarnieri, C. and Montevecchi, G., editors, *Il genio delle acque: scavi nelle piazze di Ravenna*, pages 131–44. Ravenna.
- Terpstra, T. (2019). *Trade in the Ancient Mediterranean: Private Order and Public Institutions*. Princeton.
- Terracina, F. (1991). Lastre Marmoree di Rivestimento. In Caporusso, D., editor, *Scavi MM3. Ricerche di archeologia urbana a Milano durante la costruzione della linea 3*, pages 159–64. Milan.
- Terrell, J. (2013). Social Network Analysis and the Practice of History. In Knappett, C., editor, *Network Analysis in Archaeology: New Approaches to Regional Interaction*, pages 17–41. Oxford.
- Thomas, D. (1978). The awful truth about statistics in archaeology. *American Antiquity*, 43(2):231–44.
- Thompson, H. G. (1904). *The Canal System of England*. London.
- Thompson, M. (2015). *Working on the Dock of the Bay. Labor and Enterprise in an Antebellum Southern Port*. Columbia, South Carolina Baltimore, Md.
- Throckmorton, P. (1989). The ship of Torre Sgarrata. *Tropis*, 1:263–74.

- Tiboni, F. (2009). Chioggia. Località di Motta di Cavanella d'Adige. Le operazioni di scavo e primo studio di un relitto del II-I secolo a.C. *Quaderni di Archeologia del Veneto*, 25:82–84.
- Tiranti, D., Rabuffetti, D., Salandin, A., and Tararbra, M. (2013). Development of a new translational and rotational slides prediction model in Langhe hills (north-western Italy) and its application to the 2011 March landslide event. *Landslides*, 10(2):121–138.
- Tirelli, M. (1987). Oderzo: rinvenimento di un molo fluviale in via delle Grazie. *Quaderni di Archeologia del Veneto*, 3:81–85.
- Tockner, K., Tonolla, D., Uehlinger, U., Siber, R., Robinson, C., and Peter, F. (2009). Chapter 1 - Introduction to European Rivers. In Tockner, K., Uehlinger, U., and Robinson, C., editors, *Rivers of Europe*, pages 1–21. Academic Press.
- Tomber, R. (1993). Quantitative approaches to the investigation of long-distance exchange. *Journal of Roman Archaeology*, 6:142–166.
- Tortorella, S. (1996). Considerazioni sulla sigillata tarda dell'Italia centro-settentrionale. In Picozzi, M. and Carinci, F., editors, *Studi in memoria di Lucia Guerrini*, pages 323–335. Rome.
- Trovò, R. (1996). Canalizzazioni lignee e ruota idraulica di età romana ad Oderzo (Treviso). *Quaderni di Archeologia del Veneto*, 12:119–34.
- Uggeri, G. (1978). Vie di terra e vie d'acqua tra Aquileia e Ravenna in età Romana. *Antichità Altoadriatiche*, 13:46–79.
- Uggeri, G. (1987). La navigazione interna della Cisalpina in età romana. *Antichità Altoadriatiche*, 19:305–54.
- Uggeri, G. (1990). Aspetti archeologici della navigazione interna nella Cisalpina. *Antichità Altoadriatiche*, 36:175–96.
- Uggeri, G. (1997). I canali navigabili dell'antico delta Padano. In Coen, A. and Quilici Gigli, S., editors, *Uomo, acqua e paesaggio: atti dell'incontro di studio sul tema Irreggimentazione delle acque e trasformazione del paesaggio antico: S. Maria Capua Vetere, 22-23 novembre, 1996*, Atlante tematico di topografia antica. Supplementi, pages 55–60. Rome.
- Uggeri, G. (1998). Le vie d'acqua nella Cisalpina. In Sena Chiesa, G. and Arslan, A., editors, *Optima Via. Postumia. Storia e archeologia di una grande strada romana alle radici dell'Europa, Atti del Convegno Internazionale di Studi (Cremona, 13-15 giugno 1996)*, pages 193–96. Cremona.
- Uggeri, G. (2006). *Carta archeologica del Territorio Ferrarese (F. 77 3. S.E.) Comacchio/Rivista di topografia antica Galatina*. Congendo.
- Uggeri, G. (2016). “La Romanizzazione dell'antico delta padano.” 40 anni dopo: una revisione. *Atti dell'Accademia delle Scienze di Ferrara*, 93:79–104.
- Vaccaro, E. and MacKinnon, M. (2014). Pottery and Animal Consumption: New

- Evidence from the ‘Excavating the Roman Peasant Project’. *HEROM. Journal on Hellenistic and Roman Material Culture*, 3(1):225–257.
- van den Berg, J. (2012). Rare and exotic amphorae in North-West Europe: finds from the Roman fort on the Kops Plateau, Nijmegen. *Journal of Roman Pottery Studies*, 15:215–35.
- Van Limbergen, D. (2011). *Vinum Picenum* and *Oliva Picena*. Wine and Oil Presses in Central Adriatic Italy between the Late Republic and the Early Empire. Evidence and Problems. *BABesch*, 86:71–94.
- Van Limbergen, D. (2018). The Central Adriatic Wine Trade of Italy Revised. *Oxford Journal of Archaeology*, 27:201–226.
- Van Oyen, A. (2015). The Roman City as Articulated through Terra Sigillata. *Oxford Journal of Archaeology*, 34(3):279–99.
- Van Oyen, A. (2016). *How Things Make History: The Roman Empire and its terra sigillata Pottery*. How Things Make History. Amsterdam.
- Van Oyen, A. (2017). Agents and commodities: a response to Brughmans and Poblome (2016) on modelling the Roman economy. *Antiquity*, 91:1356–1363.
- Van Oyen, A. and Pitts, M. (2017). What did objects do in the Roman world? Beyond representation. In Van Oyen, A. and Pitts, M., editors, *Materialising Roman Histories*, pages 3–19. Oxford.
- Vanetti, G. (1987). La terra sigillata di regione Maddalene. In Chieri, editor, *Museo Archeologico di Chieri*, pages 136–56. Chieri.
- Vanni Desideri, A. (2001). Gestione dello spazio urbano e del territorio in val d’aosta. analisi archeologica nell’area del teatro. In Giorcelli Bersani, S., editor, *Actes du Colloque Internationale "Les anciens et la montagne. Ecologie, religion, economie et aménagement du territoire,*, pages 261–76. Aosta.
- Veggiani, A. (1974). Le variazioni idrografiche del basso corso del fiume Po negli ultimi 3000 anni. *Padusa*, 10:39–60.
- Venturino Gambari, M., Crosetto, A., Deconca, D., Fravega, V., Ghiringhello, C., Giomi, F., Ippolito, M., Manfredi, A., and Parodi, G. (2011). Tortona, via Saccaggi - corso Repubblica. Resti del porto fluviale di età romana e impianti artigianali postmedievali. *Quaderni della Soprintendenza Archeologica del Piemonte*, 26:163–69.
- Verboven, K. (2021). Introduction: Finding a New Approach to Ancient Proxy Data. In Verboven, K., editor, *Complexity economics: building a new approach to ancient economic history*, Palgrave Studies in Ancient Economies, pages 1–18. Cham.
- Vergari, F., Della Seta, M., Del Monte, M., and Barbieri, M. (2013). Badlands denudation “hot spots”: The role of parent material properties on geomorphic processes in 20-years monitored sites of Southern Tuscany (Italy). *Catena*,

- 106:31–41.
- Veronese, F. (2011). *Via Annia II: Adria, Padova, Altino, Concordia, Aquileia: progetto di recupero e valorizzazione di un'antica strada romana*. Padua.
- Vezzoli, R., Mercogliano, P., Pecora, S., Zollo, A., and Cacciamani, C. (2015). Hydrological simulation of Po River (North Italy) discharge under climate change scenarios using the RCM COSMO-CLM. *Science of the Total Environment*, 521-22:346–58.
- Vidal, J. (1999). Anfore e Relazioni Commerciali. In Braconi, P. and Uroz Sáez, J., editors, *La villa di Plinio il Giovane a San Giustino*, pages 101–12. Perugia.
- Vidal, J. (2009). Mercantile Trade in the Upper Tiber Valley: The Villa of Pliny the Younger *in Tuscis*. In Coarelli, F. and Patterson, H., editors, *Mercator Placidissimus: The Tiber Valley in Antiquity. New research in the upper and middle river valley. Rome 27 – 28 February 2004*, pages 215–49. Rome.
- Vidal, J. and Corredor, D. (2018). The Roman Amphorae Average Capacity (AC). *Oxford Journal of Archaeology*, 37:299–311.
- Vigoni, A. (2006). Il canale interno di Iulia Concordia. Dati storici, archeologici e topografici. In Morandi Bonacossi, D., Rova, E., Veronese, F., and Zanovello, P., editors, *Tra Oriente e Occidente. Studi in onore di Elena di Filippo Balestrazzi*, pages 451–68. Padua.
- Volonte, M. (1991). Scavi a Calvatone Romana: Terra sigillata proveniente dall'area della “strada porticata”. In Facchini, G., editor, *Calvatone romana. Studi e ricerche preliminari*, pages 147–66. Milan.
- Volonte, M. (1997a). Ceramica terra sigillata: i servizi da tavola. In Filippi, F., editor, *Alba Pompeia. Archeologia della città dalla fondazione alla tarda antichità*, pages 432–50. Alba.
- Volonte, M. (1997b). Terre sigillate. In Sena Chiesa, G., editor, *Calvatone Romana. Un pozzo e il suo contesto*, pages 79–90. Bologna.
- Volonte, M., Ravasi, T., and Nicodemo, M. (2008). Le Vie delle Anfore. Il commercio di derrate alimentari a Cremona attraverso i dati dello scavo di Piazza Marconi. In Baioni, M. and Frenelli, C., editors, *Archaeotrade. Antichi commerce nella Lombardia orientale*, pages 285–303. Milan.
- Volonte, R. (1996). Le Anfore. In Passi Pitcher, L., editor, *Bedriacum: ricerche archeologiche a Calvatone*, volume 2, pages 189–208. Milan.
- Walsh, K. (2008). Mediterranean Landscape Archaeology: Marginality and the Culture–Nature ‘Divide’. *Landscape Research*, 35:547–54.
- Walsh, K. (2014). *The archaeology of Mediterranean landscapes: human-environment interaction from the Neolithic to the Roman period*. Cambridge and New York.
- Ward-Perkins, J. (1980). Nicomedia and the marble trade. *Papers of the British*

- School at Rome*, 48:23–69.
- Ward-Perkins, J. (1992). Materials, quarries and transportation (First Shuffrey Lecture). In Dodge, H. and Ward-Perkins, B., editors, *Marble in Antiquity: Collected Papers of J. B. Ward-Perkins*, Archaeological Monographs of the British School at Rome, pages 13–22. London.
- Whittaker, C. (1993). *Land, city and trade in the Roman Empire*. London.
- Whittaker, C. (1994). *Frontiers of the Roman Empire. A Social and Economic Study*. Baltimore.
- Williams, J. (2001). Roman Intentions and Romanization: Republican Northern Italy, c. 200–100 BC. In Keay, S. and Terrenato, A., editors, *Italy and the West: Comparative Issues in Romanization*, pages 91–101. Oxford.
- Willis, S. and Capulli, M. (2018). A Report on the late 1st–2nd-century-AD Venice Lido III Sewn Timber Assemblage. *The International Journal of Nautical Archaeology*, 47:343–36.
- Wilson, A. (2009a). Approaches to Quantifying Roman Trade. In Bowman, A. and Wilson, A., editors, *Quantifying the Roman Economy: Methods and Problems*, Oxford Studies on the Roman Economy, pages 213–49. Oxford.
- Wilson, A. (2009b). Indicators for Roman economic growth: a response to Walter Scheidel. *Journal of Roman Archaeology*, 22(1):71–82.
- Wilson, A. (2009c). Villas, horticulture and irrigation infrastructure in the Tiber Valley. In Coarelli, F. and Patterson, H., editors, *Mercator Placidissimus: The Tiber Valley in Antiquity. New research in the upper and middle river valley*, pages 731–68. Rome.
- Wilson, A. (2011). Developments in Mediterranean shipping and maritime trade from the Hellenistic period to AD 1000. In Robinson, D. and Wilson, A., editors, *Maritime Archaeology and Ancient Trade in the Mediterranean*, pages 33–59. Oxford.
- Wilson, A. (2012). A Forum on Trade. In Scheidel, W., editor, *The Cambridge Companion to the Roman Economy*, pages 287–91. Cambridge.
- Wilson, A. (2014). Quantifying Roman economic performance by means of proxies: pitfalls and potential. In de Callatay, S., editor, *Quantifying the Greco-Roman Economy and Beyond*, *Pragmateiai* 27, pages 147–67. Bari.
- Wilson, A. and Bowman, A. (2018a). Introduction: Trade, Commerce, and the State. In Wilson, A. and Bowman, A., editors, *Trade, Commerce, and the State in the Roman World*, Oxford Studies on the Roman Economy, pages 1–24. Oxford.
- Wilson, A. and Bowman, A. (2018b). *Trade, commerce, and the state in the Roman world*. Oxford Studies on the Roman Economy. Oxford, first edition. edition.

- Wilson, A., Schörle, K., and Rice, C. (2012). Roman ports and Mediterranean connectivity. In Keay, S., editor, *Portus and the Ports of the Roman Mediterranean*, Archaeological Monographs of the British School at Rome, pages 367–91. Rome and London.
- Zabehlicky-Scheffenecker, S. (1992). Terra sigillata tardo-padana. *Rei Cretariæ Romanæ Fautorvm*, 31/32:415–43.
- Zabehlicky-Scheffenecker, S. (2003). C. Sentius and his commercial connections. *Publications de l'Institut Français d'Études Anatoliennes*, 15(1):117–119.
- Zabehlicky Scheffenecker, S. and Sauer, R. (2000). Metodi di distinzione dei due gruppi di sigillata padana augustea trovati sul Magdalensberg. In Brogiolo, G. and Olcese, G., editors, *Produzione ceramica in area padana tra il II secolo a.c. e il VII secolo d.c.: nuovi dati e prospettive di ricerca. Convegno internazionale di Desenzano del Garda, 8-10 aprile 1999*, pages 69–78. Mantua.
- Zanchetta, G., Bini, M., Bloomfield, K., Izdebski, A., Vivoli, N., Regattieri, E., and Isola, I. (2021). Beyond one-way determinism: San Frediano's miracle and climate change in Central and Northern Italy in late antiquity. *Climatic change*, 165(1-2):1–21.
- Zanda, E. (2011). *Industria, città romana sacra a Iside. Scavi e ricerche archeologiche 1981-2003*. Turin.
- Zanetti, C. (2011). I miliari di Valentiniano e Valente in Italia: alcune considerazioni sulle titolature imperiali. In Basso, P., editor, *I miliari lungo le strade dell'impero. Atti del Convegno (Isola della Scala, 28 novembre 2010)*, pages 115–40. Verona.
- Zara, A. (2018). *La Trachite Euganea. Archeologia e storia di una risora lapidea del Veneto antico*. Padua.
- Zucca, I. (1996). Le anfore romane rinvenute a Cremona e nel suo territorio. In Facchini, G., Passi Pitcher, L., and Volonte, M., editors, *Cremona e Bedriacum in età romana I. Vent'anni di tesi universitarie*, pages 125–33. Milan.
- Zulini, E. (2017). Terra Sigillata Africana. In Maggi, P., Maselli Scotti, F., Pesavento Mattioli, S., and Zulini, E., editors, *Materiali per Aquileia: lo scavo di Canale Anfora (2004-2005)*, pages 115–35. Trieste.