
School of GeoSciences

**DISSERTATION**

For the degree of

# MSc in Geographical Information Science

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# Mapping The Phenology of European Honey Bee Nectar Flows

## Part I: Research Paper

## ii. ABSTRACT

Insect pollination is vital to both the health of our ecosystem and food production. Consequently, it is important to understand how the phenology of both pollinators and plants will be influenced by global climate change. Current satellites allow a near-daily synoptic view of the entire earth, but it is difficult linking the imagery with *in situ* events because of the difference in scale between a point and pixel. Due to their generalized foraging on a variety of plants in the 100 $km^2$ surrounding their hive, honey bees operate at a scale which may be compared to satellite data. The MODIS Aqua and Terra satellites produce daily images of the earth and the Normalized Differentiation Vegetation Index (NDVI) is able to show the "green-up" or start of spring (SOS). Locally, the phenology of nectar-producing flowers can be inferred from the honey bee nectar flow (HBNF), which is measured by the weight gain of a honey bee hive. This research investigates the link between smoothed, gap-filled NDVI data, and weight gain of hives in Slovenia, Switzerland, Belgium and Finland during 2009-2012. No correlation was found between the SOS and HBNF start day, but a notable relationship ($R^2$=0.73) was seen between NDVI SOS and HBNF midpoint (50% day) within the Alps and broadleaf forests of central Europe. This indicates that HBNF can be related to continental MODIS climate models, and that nectar flows have been advancing 0.54 days per year in central Europe.

## iii. TABLE OF CONTENTS

## iv. LIST OF ABBREVIATIONS AND ACRONYMS

ACMF – Alps Conifer and Mixed Forests

AVHRR – Advanced Very High Resolution Radiometer

DMEER – Digital Map of European Ecological Regions

EVI – Enhanced Vegetation Index

GIS – Geographical Information Science

HBNF – Honey Bee Nectar Flow

LSP – Land Surface Phenology

LST – Land Surface Temperature

MODIS – Moderate Resolution Imaging Spectroradiometer

NDVI – Normalized Difference Vegetation Index

NF – Nectar Flow

NIR – Near-Infrared Radiation

ORNL DAAC – Oak Ridge National Laboratory Distributed Active Archive Center

QA – Quality Assurance

SOS – Start of Season

VI – Vegetation Index

VIIRS – Visible Infrared Imaging Radiometer Suite

WEB – Western European Broadleaf Forests

# 1. INTRODUCTION

## 1.1 POLLINATION

Pollination is a vital part of sustaining our ecosystems and agricultural production. Almost 90% of all plant species rely on an animal visitor to transfer pollen between individuals for fertilization and reproduction (Ollerton et al., 2011). Invertebrates are the most common pollinators and an estimated 85% of European crops depend on, or benefit from, insect pollination (Williams, 1994). A variety of reports have attempted to quantify the value of pollination (Calderone, 2012) with one estimate assigning a global annual sum of €153 billion (Gallai et al., 2009). The monetary service of pollinators in wild ecosystems is even more difficult to estimate, as they are considered fundamental contributors to global biodiversity. Without their often unacknowledged work, food-webs may be disrupted, affecting us in ways difficult to quantify. Yet many pollinators face the threat of forage and habitat reduction through land development, degradation and agricultural intensification (Tilman et al., 2001). This pressure will likely continue (Potts et al., 2010).

In recent years the majority of evidence has shown our climate is changing rapidly (Walther et al., 2002; Stocker et al., 2013). One concern is the spatial or temporal disruption of pollinator and plant phenologies, leading to trophic decoupling (Visser and Both, 2005; Parmesan, 2006; National Research Council, 2007). Several studies have shown alterations in trophic relationships or energy flows in both predator-prey and plant-herbivore interactions as a consequence of changing temperatures (reviewed by Stenseth and Mysterud, 2002). Others have shown a rapid change in flowering time (Fitter and Fitter, 2002). However, there are hundreds of thousands of flowering plant species and tens of thousands of pollinating insect species (Ollerton et al., 2011) many of which appear to be in decline (Biesmeijer et al., 2006). Dependencies, abundances and the response to climate change of many species are not well known. Because of the massive number of species and the rapidness of which the climate and ecosystems are changing, it is necessary to further understand these interactions. A first step is to look at a general pollinator's relationship with its changing forage.

## 1.2 HONEY BEES

The European honey bee (*Apis mellifera*) is often considered the most important pollinator due to its generalized foraging behaviour and relative ease in management (McGregor, 1976). Honey bees gather food in the form of nectar and pollen produced by flowers at certain times of the year. A time of profuse foraging due to high nectar availability is called a honey bee nectar flow (HBNF), which can be measured by placing a hive on a scale (scale-hive) and recording the weight daily. While the phenology of flowering and leafing has been frequently studied, (e.g. Menzel et al., 2006) little work has been done on understanding the changing of HBNFs. Certain areas of the U.S.

have shown an advancing of nectar flows in Maryland (Esaias et al., 2011) which are similar to advancing floral bloom in Washington D.C (Abu-Asab et al., 2001). Similarly, Bartomeus et al. (2011) showed phenologies of bee species advancing with their floral partners.

Advancing springs or warmer temperatures would have a significant impact on beekeepers. Bee forage would be profoundly influenced by a shift in plant species distribution due to temperature (Thuiller et al., 2005). Also, the length of nectar flows are not known to increase with earlier springs; instead bees will have longer periods of activity when they are consuming stores at a higher rate, forcing total honey yields to shrink and beekeepers to provide supplemental sugar feed. Beekeepers frequently use sub-species of honey bees adapted to their local climate, and a change in seasonal timing may make using their sub-species unmanageable. The ability to understand how HBNFs are occurring at a landscape level would benefit beekeepers, and this may be possible through the use of satellite remote sensing.

### 1.3 SATELLITE REMOTE SENSING

Satellite remote sensing is frequently used in large scale phenological studies and has the potential to relate to HBNFs. Remote sensing's advantages include repeated, synoptic views over a large territory, as well as the ability to analyse archival images back to the 1980s (Reed et al., 2009). The Normalized Differential Vegetation Index (NDVI) is a graphical indicator used for monitoring vegetation changes and interpreting of the impact of climatic events on the biosphere (Zhou et al., 2001; Zhang et al., 2003; Pettorelli et al., 2005). However it is difficult to translate the NDVI measurement to phenological observations on the ground due to the difference in scale between a point (single flower/tree) and a remote sensing pixel (250 x 250 metres or more) (White et al., 2009; Schwartz and Hanes, 2010).

### 1.4 LINKING SATELLITE WITH HBNF

Because they forage on many different floral species within 6 km of their hive, honey bees hold interesting potential to compare with the satellite data, which is collected at a similar spatial scale. Nightingale et. al. (2008) observed that a study by Zhang et. al. (2007), which analysed vegetation phenology derived from a 24 year time-series of Advanced Very High Resolution Radiometer (AVHRR), corresponded directly with an advance in peak nectar flow as measured by a scale-hive in Maryland. To investigate this further they calculated 5 scale-hive metrics (Peak, Average peak, Beginning (0.05 of weight gain), Mid point and End (0.95 of weight gain)) against Moderate Resolution Imaging Spectrometer (MODIS) NDVI phenology and found the strongest correlation between the Midpoint (50% scale-hive peak) and NDVI ($R^2$ =0.8). Furthermore, Esaias et. al. (2011), who oversees a network of scale-hives in the United States, reported a correlation

($r^2$=0.737, n=61) between MODIS NDVI and 50% nectar flow in the tree-dominated Eastern North America.

## 1.5 RESEARCH QUESTION AND HYPOTHOSIS

In order to better understand changing phenologies of plants and bees, this research will investigate if a similar correlation exists in parts of Europe where detailed scale-hive records have been made available for research. HBNF metrics will be calculated with scale-hive data from 2009-2012 in Slovenia, Belgium, Switzerland and Finland, and a link between these and satellite data will be explored. Following research in the U.S., it is hypothesized that certain ecological zones, notably temperate forests, will show a correlation between the MODIS-derived SOS and the mid-point of the nectar flow.

Specifically this research will address the following questions:

1. Does a relationship exist between NDVI and HBNF in Europe?
    1.1. Is there a metric (HBNF start, HBNF 50%) which shows the strongest correlation?
2. Do certain years have a stronger relationship than others?
3. Do certain countries have a stronger relationship than others?
4. Does the relationship differ spatially depending on land cover or ecological region?

## 2. LITERATURE REVIEW

### 2.1 HONEY BEES

The European honey bee is one of seven species in the genus *Apis*. It is a eusocial insect, living a complex social system in large colonies of up to 80,000 members. Nectar and pollen comprise the complete honey bee diet, with colonies requiring 120 kg of nectar and 20 kg of pollen annually (Seeley, 1995). Bees process and dehydrate the nectar to store it as honey. Unlike many wild bee species, which have an obligate larval or adult diapause during the winter, honey bees remain active within a cluster and regulate temperature by physically generating heat with their wing muscles. Without sufficient honey collected during the spring and summer, the bees will perish from cold and starvation.

### 2.2 FORAGE

To gather food and water honey bees need to leave the hive and enter the surrounding environment. A colony acts as a large, connected entity which can spread in separate directions over great distances simultaneously. Scout bees must expeditiously scour the landscape to discover sources of nectar or pollen shortly after they come into bloom. They are quite effective at finding forage; a colony was shown to have a 0.5 probability of finding a small patch of flowers (100 $m^2$, equal to 1/125,000 of their average search area) within 2000 meters of their hives (Seeley, 1987).

With the flowers found, the scout bees must quickly return to recruit other foragers before the weather changes, blossoms fade or darkness descends. The scouts communicate the distance, direction and quality of the flower patch to other foragers through a precise dance language first decoded by Karl Von Frisch (1967). Honey bees are highly economical foragers and register the profitability of a nectar source by sensing the energetic efficiency of their foraging (Seeley, 1994). With the information from a number of scouts, nearly a quarter of the hive – several thousand bees – will commence in foraging on a few of these high quality patches. This process is continually evaluated throughout the day as weather and nectar conditions change (Visscher and Seeley, 1982).

### 2.3 SCALE-HIVE

In North America and Europe, HBNFs typically are short and profuse (a matter of weeks) where honey bees must gather as much food as possible to survive long periods of dearth (Seeley, 1995). A hive will gain weight when the bees are harvesting nectar, and a common practice for both beekeepers and researchers is to keep a hive on a stationary scale and record the daily or weekly weight to better understand the current status of the colony (McLellan, 1977; Szabo and Lefkovitch, 1991; Harbo, 1993). Weighing is fast, requires little training, does not disturb the bees and can be done at any time of the year. The daily running average, which is the average of all weights 12

hours before after that point, represents the change in food stores with a reasonable degree of confidence (Meikle et al., 2008).

Buchmann and Thoenes (1990) first proposed the use of an electronic scale, which when connected with a datalogger, provides a continuous weighing of the hive (Meikle et al., 2006). The past decade has seen a rise in use of electronic scales by researchers and beekeeping associations in Europe and North America. Weighing hives precisely and frequently can produce within-day variation and show useful information on colony dynamics and daily ecology. If shared or published, this scale-hive data becomes a historical educational record. When looked at over a number of years, it can possibly detect land-cover and/or climate-related changes. While scale-hives are collected at an *in situ* point, they reflect the status of many square kilometres – a similar scale to satellite imagery.

## 2.4 NORMALIZED DIFFERENCE VEGETATION INDEX

One of the most common uses of satellite imagery is to monitor the biosphere and NDVI is a frequently-used indicator of vegetation (Tucker, 1979; Sellers, 1985). Satellite-derived NDVI data has the potential to provide temporal indicators of the onset, end, peak and duration of vegetation greenness as well as the rate of growth, senescence and periodicity of photosynthetic activity (Reed et al., 1994; Myneni et al., 1997). The theoretical basis for empirical-based vegetation indices is derived from the typical spectral reflectance of leaves; reflected energy is low in the visible spectrum as a result of high absorption by photosynthetically active pigments, with maximum absorption in the blue (~470m) and red (~678 nm) wavelengths (Jensen, 2006). Much of the near-infrared radiation (NIR) is scattered making the contrast between red and NIR a sensitive measure of vegetation quantity. Maximum red-NIR differences occur over a full canopy and minimal occur when there is little to no vegetation. NDVI is a normalized transform of the NIR to red reflectance ratio (Equation 1) designed to standardize vegetation index (VI) values to between -1 and +1 (Deering and Rouse, 1975; Solano et al., 2010):

$$NDVI = \frac{\rho NIR - \rho red}{\rho NIR + \rho red} \qquad \textit{Equation 1}$$

where ρNIR is infrared and ρred is red reflectance.

The MODIS algorithm calculates NDVI red and near-infrared reflectance centred at 645-nanometres and 858-nanometres respectively (Huete et al., 1999) and is computed from atmospherically correlated bi-direction surface reflectances that have been masked for water, clouds, heavy aerosols and cloud shadows. MODIS is an important part of the continuing NDVI

record begun in 1982 by AVHRR, and its products were designed to provide consistent spatial and temporal comparisons of global vegetation conditions in support of change detection and phenological and biophysical interpretations (Huete et al., 2002; Justice et al., 2002). With the ability of remote sensing to work at a regional or continental scales, modelling phenological patterns related to climate change has become possible (Schwartz and Reed, 1999; De Beurs and Henebry, 2004; Zhang et al., 2007, 2009).

## 2.5 LINKING NDVI WITH GROUND MEASUREMENTS

Linking traditional phenological indicators like budburst, leafing, flowering and senescence with remote sensing has great potential to enhance our ability to track the biotic response to climate change (Beaubien and Hall-Beyer, 2003). Yet finding connection has been elusive due to spatial and temporal scale mismatch, complex data interpretation and additive noise from several factors including atmospheric disturbances, solar radiation effects, cloud cover or snow cover (Reed et al., 1994; Schwartz and Reed, 1999; Zhou et al., 2001; White et al., 2005).

Because vegetation observed by satellite sensors integrates signals from abiotic and biotic surfaces, there is a distinct difference between the measurement of individual plant events and satellite-based phenology, which is often called land surface phenology (LSP) (De Beurs and Henebry, 2004). One frequently sought after measure of LSP is the start of season/spring (SOS), also known as the “green up” or “green wave.” The SOS is defined as the rapid sustained increase in remotely-sensed greenness after the longest annual period of photosynthetic senescence (White et al., 2009). SOS is an interconnected composite of biospheric events that is of special interest in the mid-latitudes, as it appears to be important for accurate computation of net primary productivity (Running and Nemani, 1991; White et al., 1999), a sensitive measure of the impacts of global change (Schwartz and Reiter, 2000; Menzel et al., 2001) and connected with springtime changes in net ecosystem exchange, sensible heat and latent heat fluxes (Wilson and Baldocchi, 2000; Schwartz and Crawford, 2001).

## 2.6 CALCULATING SOS

There have been many methods devised to calculate SOS (de Beurs and Henebry, 2010). However the nature of satellite data makes it difficult to extract phenological metrics directly, and the data often requires quality screening and smoothing to minimize atmospheric noise or compensate for the absence of data. A major hurdle in comparing SOS to ground measurements is the lack of observations sufficient to account for spatial heterogeneity at the landscape scale. Efforts have been made to compare satellite phenology with ground-based phenology models (Schwartz and Reed, 1999; Schwartz et al., 2002). Others have modified point sampling phenology by

upscaling high density/frequency observations (Liang et al., 2011) or supplemented medium resolution imagery (50 m) to bridge coarse resolution (500m) and plot level phenology (Fisher et al., 2006). The success of these studies suggests that sampling phenology at landscape level holds the best promise to bridge the gap between *in situ* measurements and satellite imagery.

### 2.7 LSP AND HONEYBEES

Because NDVI measures the greenness of the landscape generated mainly by leaves, many LSP studies have tried to link SOS with bud-burst. Leafing is an unimportant phenological event for honey bees. However Studer et al., (2007) found a multi-species index, including the flowering of several species, correlated with the SOS, and Zhang et al., (2006) showed a relationship between the mean NDVI SOS and mean flowering date of *in situ* measurements across Canada. While NDVI does not measure flowering directly, continental NDVI is best explained by temperature and precipitation variations (Los et al., 2001); two factors which are also important for flowering and nectar flow.

Unlike a flower or a tree, which is a static point representing a single species, a honey bee colony operates on a similar spatial scale as satellite data. Foraging honey bees cover 100 $km^2$ surrounding the hive and interact with a range of melliferous and pollen-producing species (Visscher and Seeley, 1982). The combination of the scale at which they operate as well as generalist foraging provide a novel form of *in situ* phenology which can be related to satellite LSP.

## 3. DATA AND METHODS

### 3.1 STUDY AREAS

Study areas were limited to locations in Slovenia, Belgium, Switzerland and Finland with available scale-hive data (Figure 1, Table 1). Three sites were selected from each country with the criteria of having precise, regularly-collected data from two or three spring seasons during 2009-2013. Certain records included notes on the species providing the nectar flow (NF) and hive manipulations i.e. feeding, adding honey supers or harvesting honey. Days with hive manipulations were adjusted to a null change. Other inconsistencies such as large weight losses (>2 kg), isolated weight gains during nectar dearth and large weight gains (>10 kg) were also removed from the data and replaced with a null change.

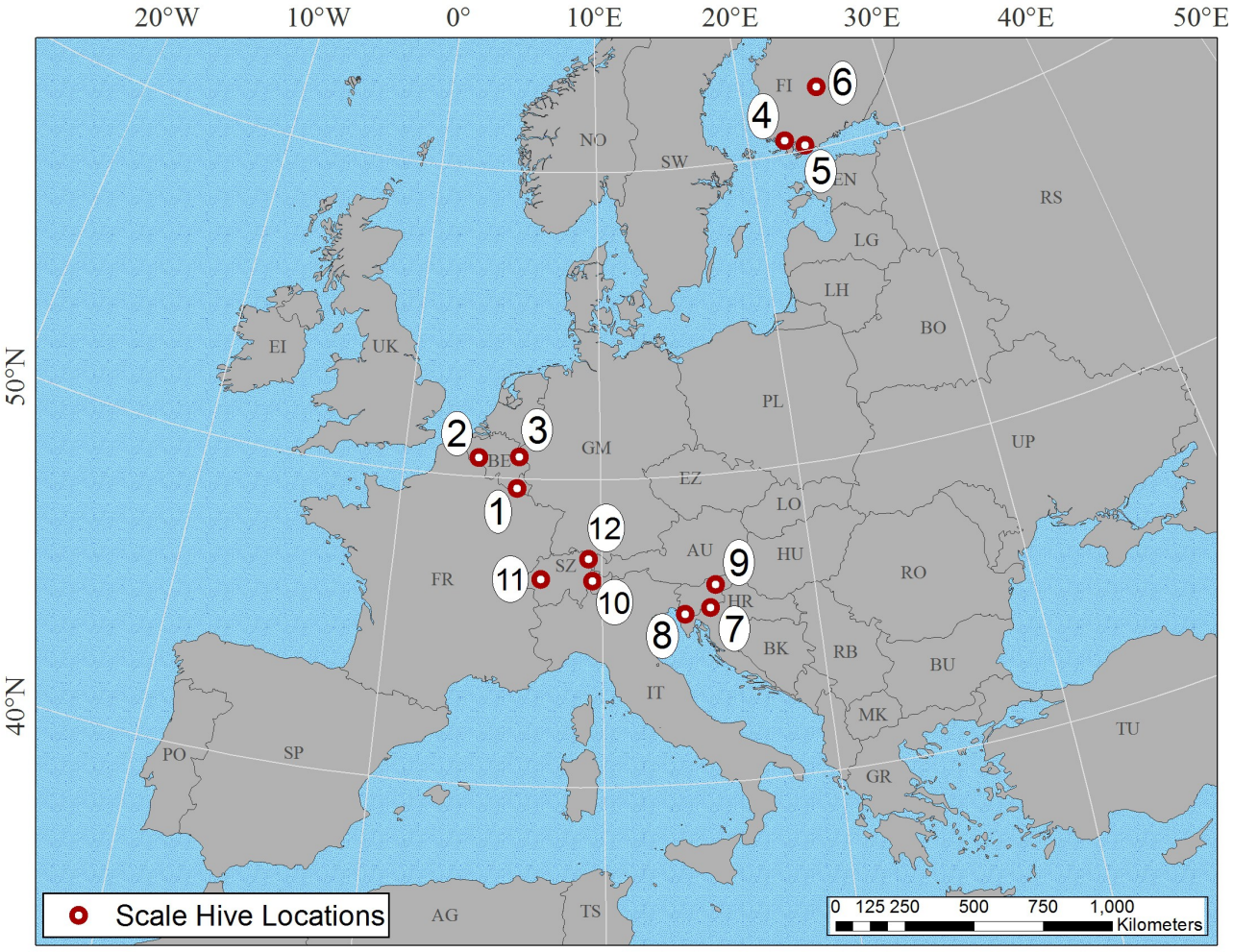


*Figure 1: Locations of scale-hives*

| ID | Country | Hive Location | Hive Type | Y | X | Elev.(m) | DMEER | Surrounding Forage | Hive Data Availability | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | 2009 | 2010 | 2011 | 2012 | 2013 |
| 1 | Belgium | Arlon | Unknown | 49.683265 | 5.799919 | 376 | Western European Broadleaf forests | Rapeseed, urban gardens, forest | | X | X | X | |
| 2 | Belgium | Ath | Unknown | 50.628907 | 3.761358 | 38 | Southern Temperate Atlantic | Hedgerows, urban gardens | | X | X | | |
| 3 | Belgium | Aubel | Unknown | 50.704825 | 5.857697 | 225 | Southern Temperate Atlantic | Acacia, Maize, Apple, Hawthorn | | X | X | | |
| 4 | Finland | Kaarina | Langstroth | 60.43597 | 22.43225 | 38 | Sarmatic mixed forests | Unknown | | | X | X | X |
| 5 | Finland | Karjalohja | Langstroth | 60.18339 | 23.65175 | 53 | Scandinavian and Russian taiga | Unknown | | | X | X | |
| 6 | Finland | Jämsä | Langstroth | 61.96423 | 25.30072 | 117 | Scandinavian and Russian taiga | Unknown | | | X | X | |
| 7 | Slovenia | Kočevski Rog – Podstenice | AŽ | 45.708642 | 15.029349 | 535 | Pannonian mixed forests | Oak, maple, fir, lime, spruce | | X | X | X | |
| 8 | Slovenia | Koper – Dekani | AŽ | 45.541377 | 13.832958 | 65 | Illyrian deciduous forests | Oak, Chestnut, Ash, Acacia | | X | X | X | |
| 9 | Slovenia | Zreško Pohorje | AŽ | 46.440454 | 15.351017 | 1143 | Alps conifer and mixed forests | Maple, fir, red pine, spruce, cherry | | X | X | X | |
| 10 | Switzerland | Obervaz | CH-Box | 46.715093 | 9.537611 | 1162 | Alps conifer and mixed forests | Mountain flowers, Hedges, forest | X | | X | X | |
| 11 | Switzerland | Posieux (Grangeneuve) | Dadant | 46.764327 | 7.09769 | 630 | Western European Broadleaf forests | Meadow, orchard, forest, hedgerows | X | X | X | | |
| 12 | Switzerland | St. Gallen | Modified CH-box | 47.425059 | 9.376588 | 671 | Western European Broadleaf forests | Urban gardens, Fruit trees, Mixed forest | | | X | X | |

*Table 1: Geographical data of scale-hives. All bees are* Apis mellifera*, subspecies unknown*

### 3.2 DIGITAL MAP OF EUROPEAN ECOLOGICAL REGIONS

The Digital Map of European Ecological Regions (DMEER) delineates and describes ecological distinct areas in Europe based on climatic, topographic and geobotanical European data. The map of ecological regions attempts to show the extent of areas with relatively homogeneous ecological conditions, within which, comparisons and assessments of different expressions of biodiversity are meaningful (Painho et al., 1996). DMEER (2000) was derived from work done by Bunce (1995) and Bohn (1994). Because no honey bee forage map of Europe exists, DMEER was used to assign hives ecological zones for means of comparison.

### 3.3 SCALE-HIVE DATA

#### 3.3.1 SLOVENIA

Scale-hive data was acquired through personal communication with Jure Justinek of Čebelarske zveze Slovenije. Data was provided in the form of daily weight change and a suitable weight (30 kg) was assigned at the beginning of season. Location data was found on the website: https://ecebelar.czs.si (Figure 2)

#### 3.3.2 BELGIUM

Belgian scale-hive data was acquired through the Centre Apicole de Recherche et Information. Scale-hive data was collected automatically every two hours throughout the day (0600-2200), but the weight used in this research came from the day's final weigh-in (2200). Weight and location data were acquired through the website: http://www.cari.be/balances/ (Figure 3)

#### 3.3.3 SWITZERLAND

Swiss scale-hive data was acquired through Verein Deutschschweizerischer Und Rätoromanischer Bienenfreunde (VDRB) http://www.vdrb.ch/service/waagvlker.html. The hive weight was collected by datalogger every two hours from 0500-2100 and uploaded to a central server. Data contained very few notes and website stated that large variations in weight were not commented upon and the viewer must use their own judgement. Coordinates were given through personal communication with René Zumsteg of VDRB (Figure 4).

#### 3.3.4 FINLAND

Finish scale-hive data and locations were acquired personal communication with Ari Seppälä, Beekeeping Advisor of Finland (Figure 5). Data for Finish hives was from 2011-2012, with one season in Kaarina in 2013. No notes were provided with the data.

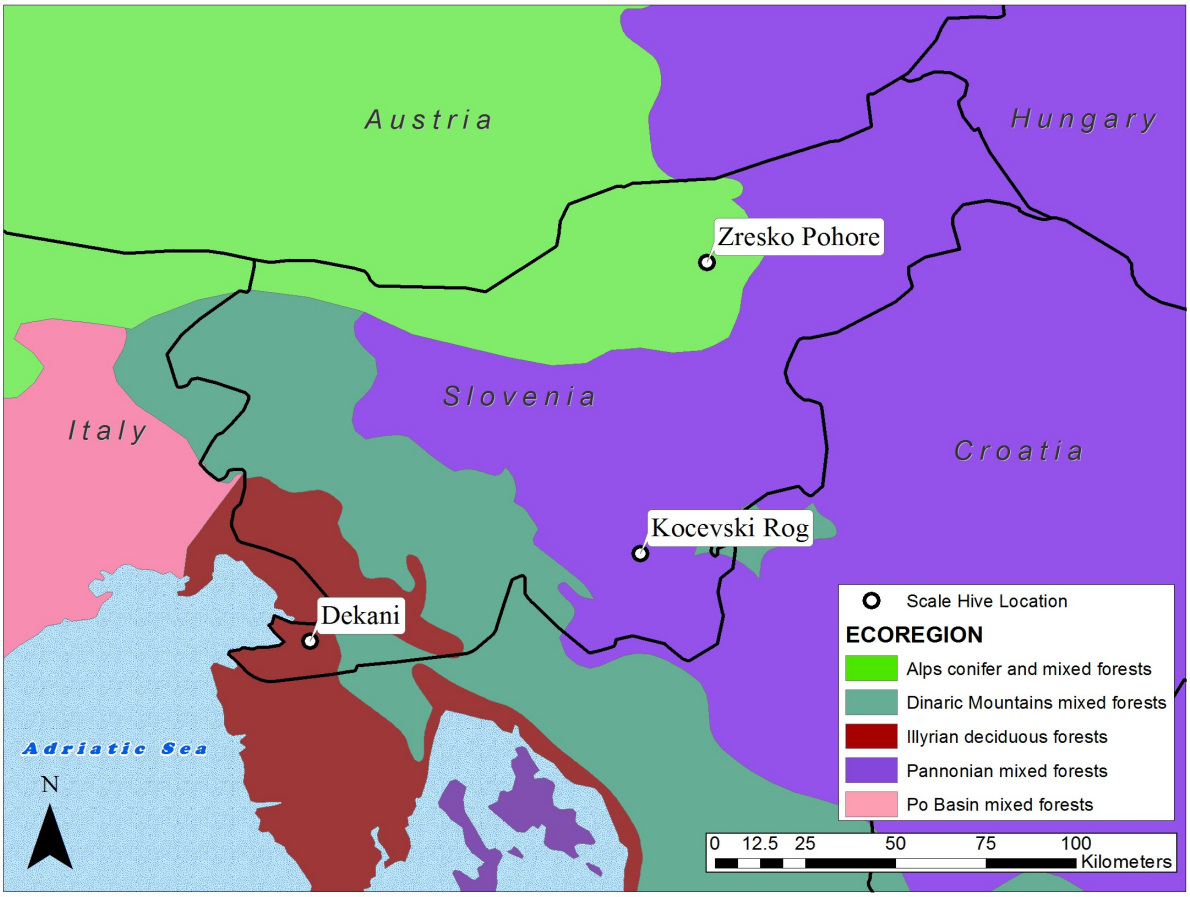


*Figure 2: Slovene Hives in DMEER zones*

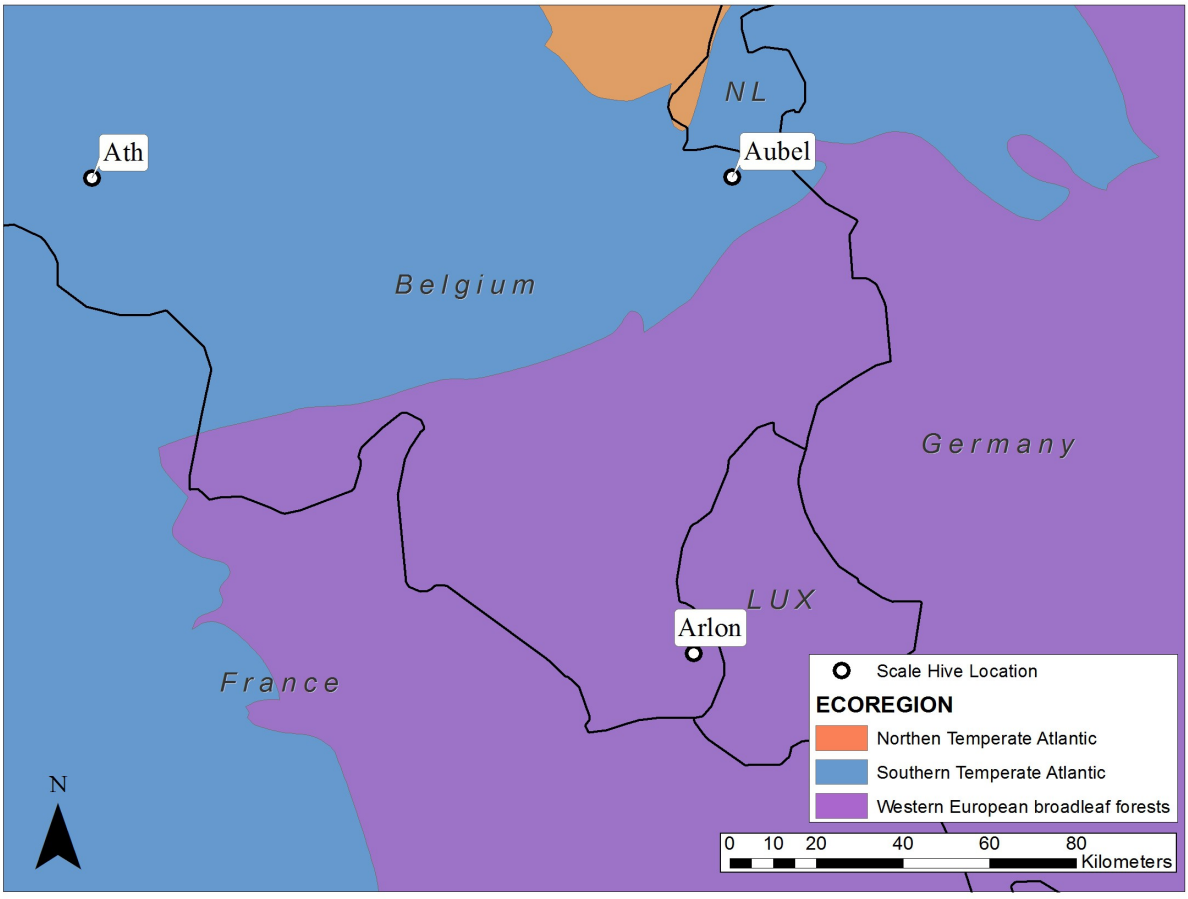


*Figure 3: Belgian Hives in DMEER zones*

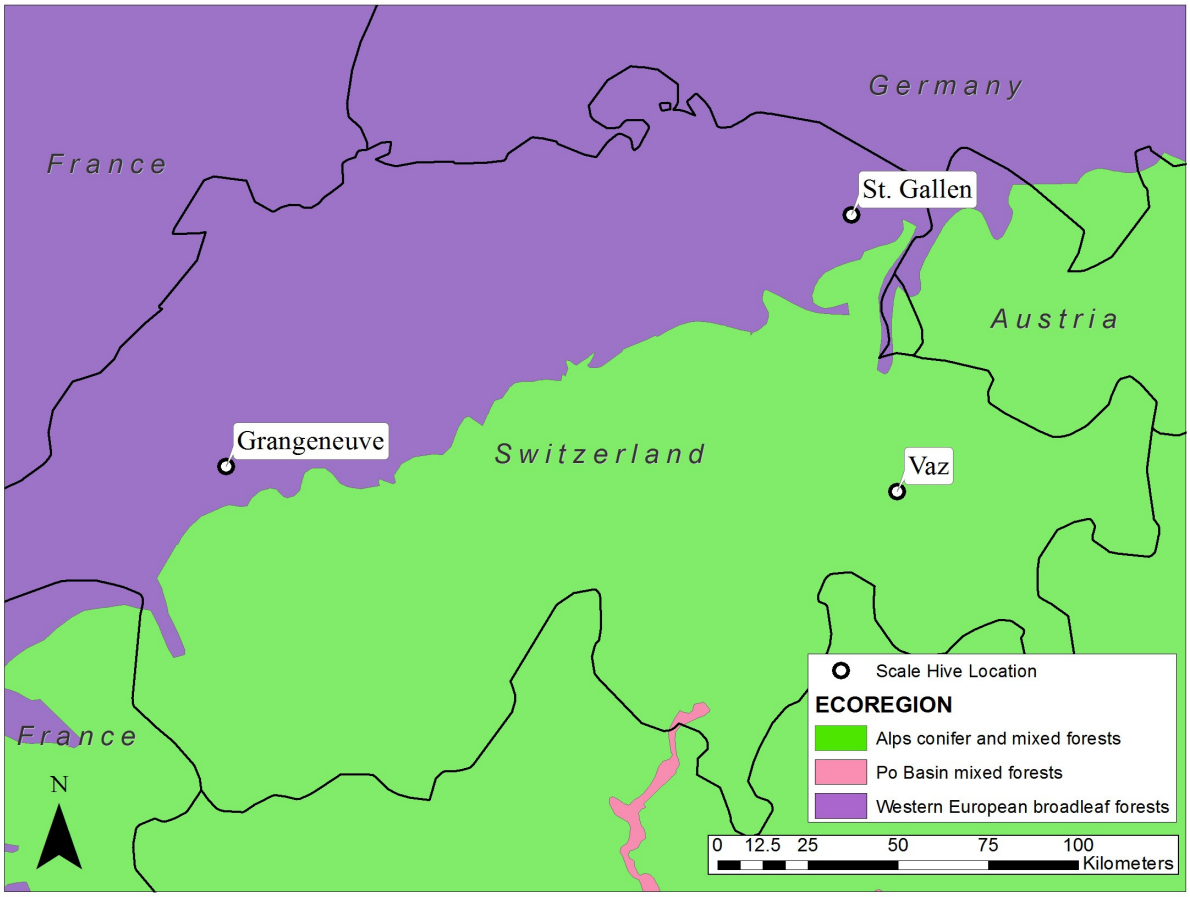


*Figure 4: Swiss scale-hives in DMEER zones*

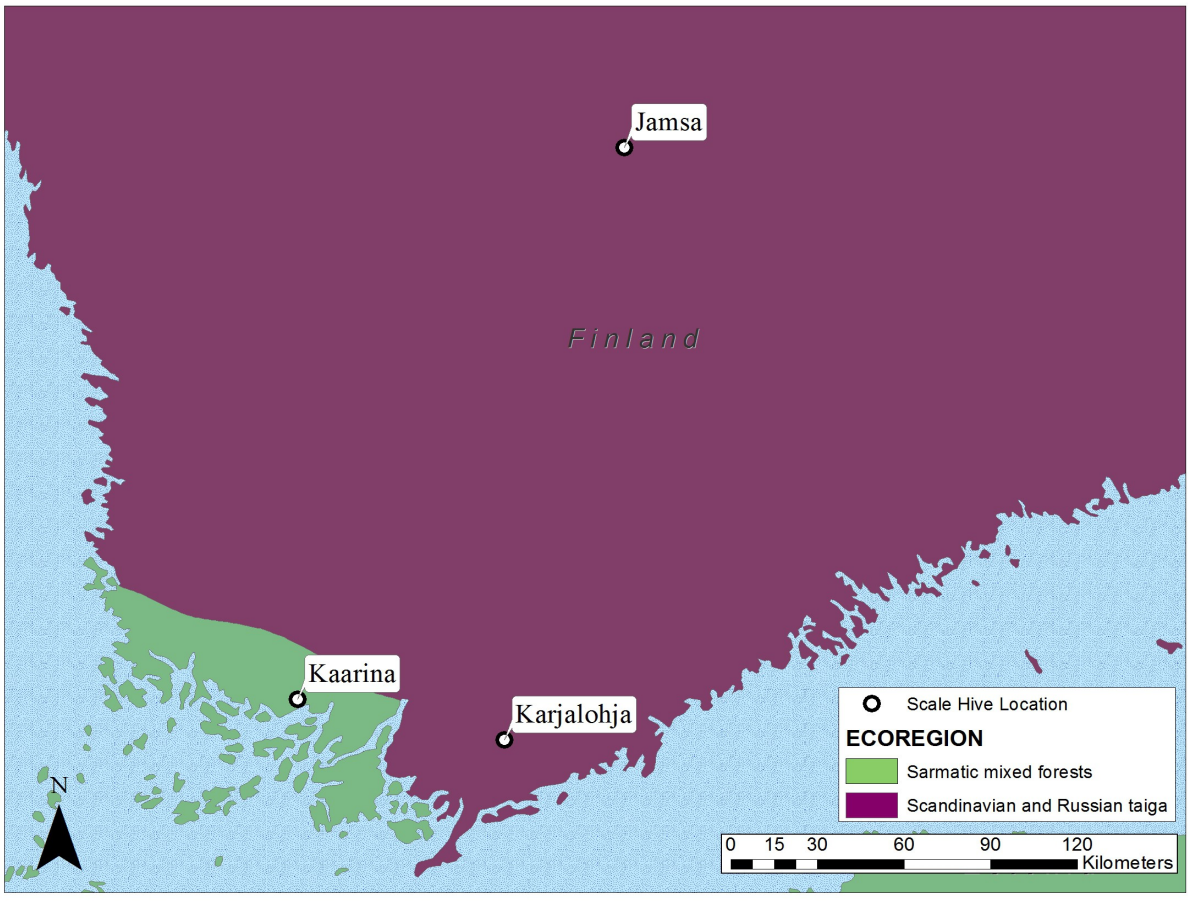


*Figure 5: Finish scale-hives in DMEER zones*

### 3.4 HONEY BEE NECTAR FLOW METRICS

For many hives, the spring HBNF was straightforward (Figure 6). The rapid gain in adjusted weight (blue line) marked the beginning of the flow (green dot), while the levelling-off indicated

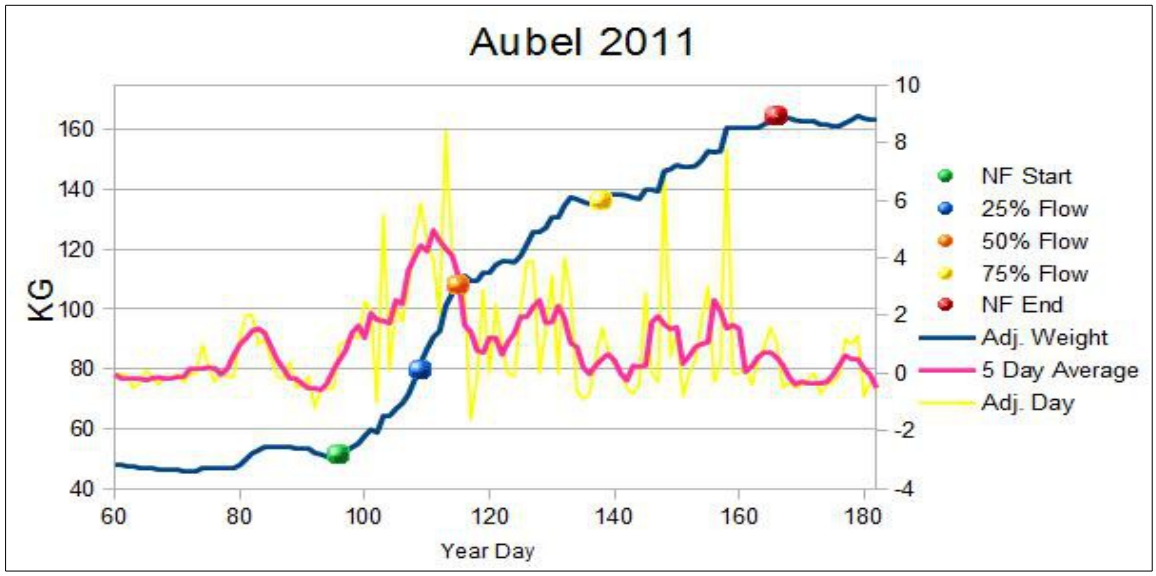


*Figure 6: An example of scale-hive metrics from Aubel, Belgium in 2011*

the end (red dot). Other seasons and locations had a less distinct weight gain, where, because of rainfall, variable nectar secretion or other reason, the NF fragmented. An attempt was made to identify the main spring nectar flow (at times consisting of two or three broken flows) between day 90 and day 180. Flows that began after day 180 or continued past the day 200 were considered summer NFs and not included as the spring HBNF. Exceptions were made in Finland, where flows occur much later due to their northern latitudes.

Total nectar flow weight was calculated by subtracting the weight of NF start from NF end. Duration was calculated by subtracting the NF start day from end day. Total nectar flow weight was quartered and 25%, 50% and 75% NF were calculated. The day in which the hive surpassed those weights were used for analysis.

### 3.5 MODIS NDVI

MODIS NDVI was from the dataset MOD13Q1 acquired at the Oak Ridge National Laboratory Distributed Active Archive Center (ORNL DAAC: http://daac.ornl.gov). This was collected by the Terra satellite with a ground sampling distance of 250 meters and a 16 day composite window. MODIS data with

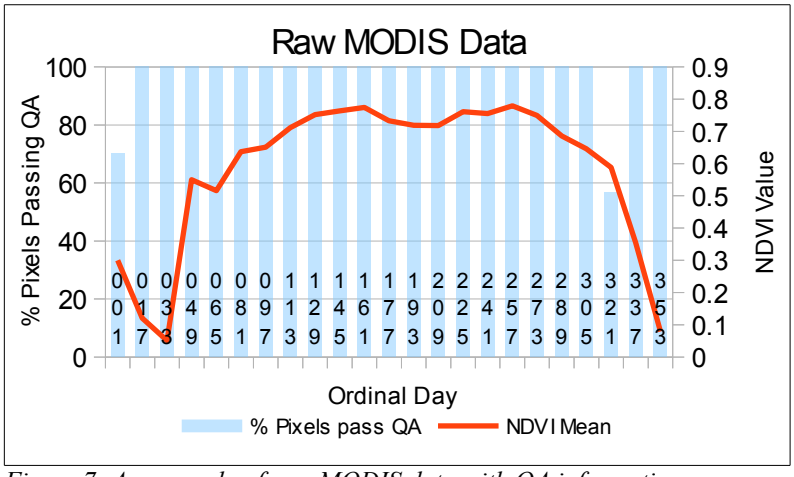


*Figure 7: An example of raw MODIS data with QA information*

the areal extent of approximately 6.25 by 6.25 kilometres (pixels n=625) was selected with the centre coordinate being the location of the hive. This area was thought to encompass the foraging range of honey bees during the spring season (Blomstedt, 2014: Section 2.4). The timespan of VI products downloaded was from January 2009 – December 2012 (except for Kaarina, Finland which included 2013). All non-vegetated pixels (Classified 13 for Urban and Built Up and 0 for Water) were removed from analysis. Each dataset included the Quality Assurance (QA) metadata describing its usability and usefulness (Roy et al., 2002). All unprocessed and cloudy pixels (ranked -1, 2 3) were removed. Following the methods of Esaias (2011) and Zhang (2006), the remaining pixels were averaged to create an overall mean for each 16 day capture.

### 3.6 TIMESAT

In order to extract meaningful information from NDVI data, it is necessary to suppress short term variation by using running averages, running medians or a compound smoother. TIMESAT is a software package based on MATLAB designed for extracting seasonal parameters (Jönsson and Eklundh, 2002, 2004, 2011). TIMESAT offers three smoothing functions and this research used asymmetric Gaussian method due its robustness against noise and incomplete time-series (Gao et al., 2008). The methodology of this research is based on Tan et al. (2011) who further enhanced the TIMESAT algorithm using night land surface temperature (LST) from MODIS product MOD11A2 to produce gap-filled NDVI time-series (Blomstedt, 2014: Section 3.8).

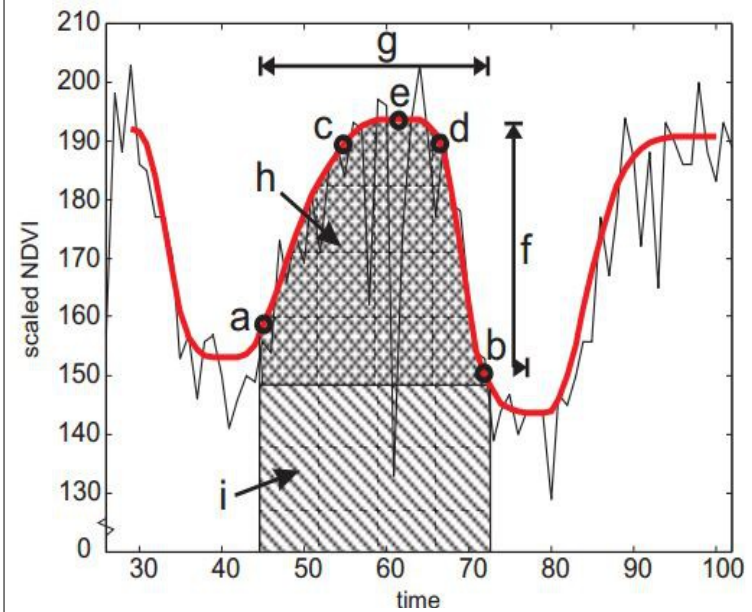


*Figure 8: An example of TIMESAT phenological parameters: Black line is raw NDVI and red line is smoothed Gaussian NDVI. Points (a) and (b) mark, respectively, start and end of the season. Points (c) and (d) give the 80 % levels. (e) displays the point with the largest value. (f) displays the seasonal amplitude and (g) the seasonal length. Finally, (h) and (i) are integrals showing the cumulative effect of vegetation during the season (Jönsson and Eklundh, 2011)*

With a smoothed NDVI curve, the start of season can be marked by defining a threshold (amplitude or absolute value). 15% amplitude was used to designate the SOS, as this is thought to be when the majority of vegetation had revived from it's dormant state (Blomstedt, 2014: Section 2.9). TIMESAT also offers the option to assign weight to each data capture. Data captures which contained more than half pixels (n=315) with a QA = 1 were only given a 75% weight. Data captures with more than 80% QA = 1 (n=500), or more than 10% QA = 3 were given a 50% weight.

# 4. RESULTS

## 4.1 HBNF DATA

*Table 2: Scale-hive data by location. Other than columns "year" and "duration," numbers represent ordinal dates*

| Country | Hive | Year | TIMESAT SOS (15%) | NF Start | NF Duration | 25% Flow | 50% Flow | 75% Flow | NF End |
|---|---|---|---|---|---|---|---|---|---|
| Belgium | Arlon | 2010 | 99 | 138 | 29 | 141 | 144 | 156 | 167 |
| | | 2011 | 82 | 81 | 77 | 113 | 127 | 136 | 158 |
| | | 2012 | 81 | 125 | 37 | 128 | 131 | 140 | 162 |
| | Ath | 2010 | 70 | 104 | 41 | 118 | 134 | 140 | 145 |
| | | 2011 | 86 | 126 | 41 | 150 | 155 | 164 | 167 |
| | Aubel | 2010 | 64 | 104 | 40 | 114 | 118 | 140 | 144 |
| | | 2011 | 57 | 96 | 70 | 109 | 115 | 138 | 166 |
| Finland | Jämsä | 2011 | 103 | 149 | 44 | 162 | 171 | 182 | 193 |
| | | 2012 | 86 | 142 | 49 | 167 | 181 | 185 | 191 |
| | Kaarina | 2011 | 97 | 179 | 57 | 183 | 188 | 193 | 236 |
| | | 2012 | 86 | 141 | 190 | 49 | 167 | 182 | 187 |
| | | 2013 | 104 | 149 | 50 | 180 | 187 | 191 | 199 |
| | Karjalohja | 2011 | 99 | 129 | 64 | 163 | 180 | 184 | 193 |
| | | 2012 | 93 | 141 | 59 | 161 | 167 | 184 | 200 |
| Slovenia | Dekani | 2010 | 89 | 124 | 56 | 134 | 141 | 161 | 180 |
| | | 2011 | 75 | 118 | 17 | 123 | 127 | 130 | 135 |
| | | 2012 | 81 | 121 | 12 | 126 | 128 | 130 | 133 |
| | Kočevski Rog | 2010 | 91 | 140 | 59 | 165 | 186 | 190 | 199 |
| | | 2011 | 82 | 126 | 55 | 133 | 147 | 169 | 181 |
| | | 2012 | 85 | 166 | 22 | 172 | 182 | 184 | 188 |
| | Zreško Pohorje | 2010 | 81 | 155 | 43 | 178 | 183 | 191 | 198 |
| | | 2011 | 73 | 109 | 65 | 130 | 153 | 166 | 174 |
| | | 2012 | 97 | 118 | 68 | 169 | 172 | 176 | 186 |
| Switzerland | St. Gallen | 2011 | 54 | 104 | 28 | 113 | 123 | 127 | 132 |
| | | 2012 | 65 | 115 | 17 | 117 | 120 | 124 | 132 |
| | Grangeneuve | 2009 | 64 | 118 | 27 | 126 | 130 | 135 | 145 |
| | | 2010 | 68 | 104 | 42 | 113 | 118 | 142 | 146 |
| | | 2011 | 56 | 105 | 25 | 111 | 113 | 114 | 130 |
| | Vaz | 2009 | 110 | 124 | 45 | 135 | 142 | 148 | 169 |
| | | 2011 | 114 | 106 | 48 | 114 | 129 | 140 | 154 |
| | | 2012 | 129 | 142 | 44 | 156 | 165 | 179 | 186 |

*Table 3: Properties of HBNF by country. Other than range column and duration rows, numbers represent ordinal date.*

| Country | Metric | Mean | Median | Maximum | Minimum | Range |
|---|---|---|---|---|---|---|
| Belgium | NF Start | 111 | 104 | 138 | 81 | 57 |
| | Duration (days) | 48 | 41 | 77 | 29 | 48 |
| | NF 50% | 132 | 131 | 155 | 115 | 40 |
| | NF End | 158 | 162 | 167 | 144 | 23 |
| Finland | NF Start | 147 | 142 | 179 | 129 | 50 |
| | Duration (days) | 53 | 50 | 64 | 44 | 20 |
| | NF 50% | 179 | 181 | 188 | 167 | 21 |
| | NF End | 200 | 193 | 236 | 190 | 46 |
| Slovenia | NF Start | 131 | 124 | 166 | 109 | 57 |
| | Duration (days) | 44 | 55 | 68 | 12 | 56 |
| | NF 50% | 158 | 153 | 186 | 127 | 59 |
| | NF End | 175 | 181 | 167 | 133 | 34 |
| Switzerland | NF Start | 115 | 111 | 142 | 104 | 38 |
| | Duration (days) | 35 | 35 | 48 | 17 | 31 |
| | NF 50% | 130 | 126 | 156 | 113 | 43 |
| | NF End | 149 | 146 | 186 | 130 | 56 |
| Total | NF Start | 126 | 124 | 179 | 81 | 98 |
| | Duration (days) | 45 | 44 | 77 | 12 | 65 |
| | NF 50% | 150 | 144 | 188 | 113 | 75 |
| | NF End | 170 | 169 | 236 | 130 | 106 |

*Table 4: HBNFs by year. 2012 not included due to Finish data available only during 2012-13. Other than range column and duration rows, numbers represent ordinal date.*

| Year | Metric | Mean | Median | Maximum | Minimum | Range |
|---|---|---|---|---|---|---|
| 2010 | NF Start | 124 | 124 | 155 | 104 | 51 |
| | Duration (days) | 44 | 42 | 59 | 29 | 30 |
| | NF 50% | 146 | 141 | 186 | 118 | 68 |
| | NF End | 168 | 167 | 199 | 144 | 55 |
| 2011 | NF Start | 119 | 114 | 179 | 81 | 98 |
| | Duration (days) | 49 | 52 | 77 | 17 | 60 |
| | NF 50% | 144 | 138 | 188 | 113 | 75 |
| | NF End | 168 | 167 | 236 | 130 | 106 |

Tables 1-3 describe the properties of the HBNFs by location, country and year. All metrics showed large variation, with the ranges of each metric rarely under 5 weeks. Belgium had the earliest NFs while Finland the latest. Finland had the longest mean NF, while Slovenia and Belgium had the longest individual flows. Slovenian hives showed the greatest range of a minimum and maximum flow with 56 days. The mean duration of all flows is around 9 weeks in length. The curvature of nectar flows also varied greatly (Appendix A). Some HBNFs began and ended sharply while others started slowly and continued of a long period of time. In some cases a flow would be interrupted for a week or more before resuming.

### 4.2 START OF SEASON – HBNF METRICS

Figures 9-12 show examples of the Gaussian smoothed NDVI relative to scale hive data. For all scale-hives, the SOS began an average of 41 days before NF starts, but two seasons (Arlon 2011 and Vaz 2011) had the NF start prior to SOS. TIMESAT SOS (15%) showed a weak positive relationship to all HBNF metrics ($R^2$ =0.2 to 0.33) with HBNF start and 50% seen in figures 13-14. However the regression lines have similar slopes and figure 14 shows a group of points following a linear pattern below a less-formed upper group. HBNF metrics for the year 2011 showed similar low correlation ($R^2$ = 0.25 to 0.42, Appendix B). Belgium and Switzerland exhibited the strongest relationships (Figures 15-16) while Slovenia ($R^2$= 0.24) and Finland ($R^2$=0.00) were insignificant.

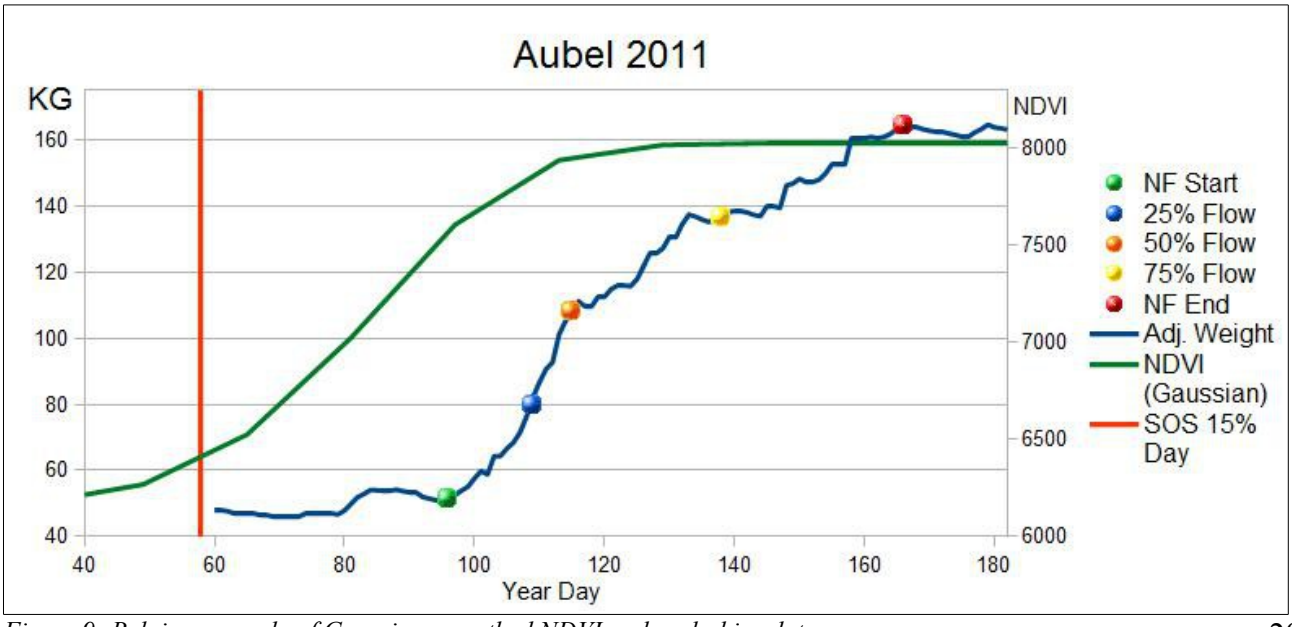


*Figure 9: Belgian example of Gaussian smoothed NDVI and scale-hive data.*

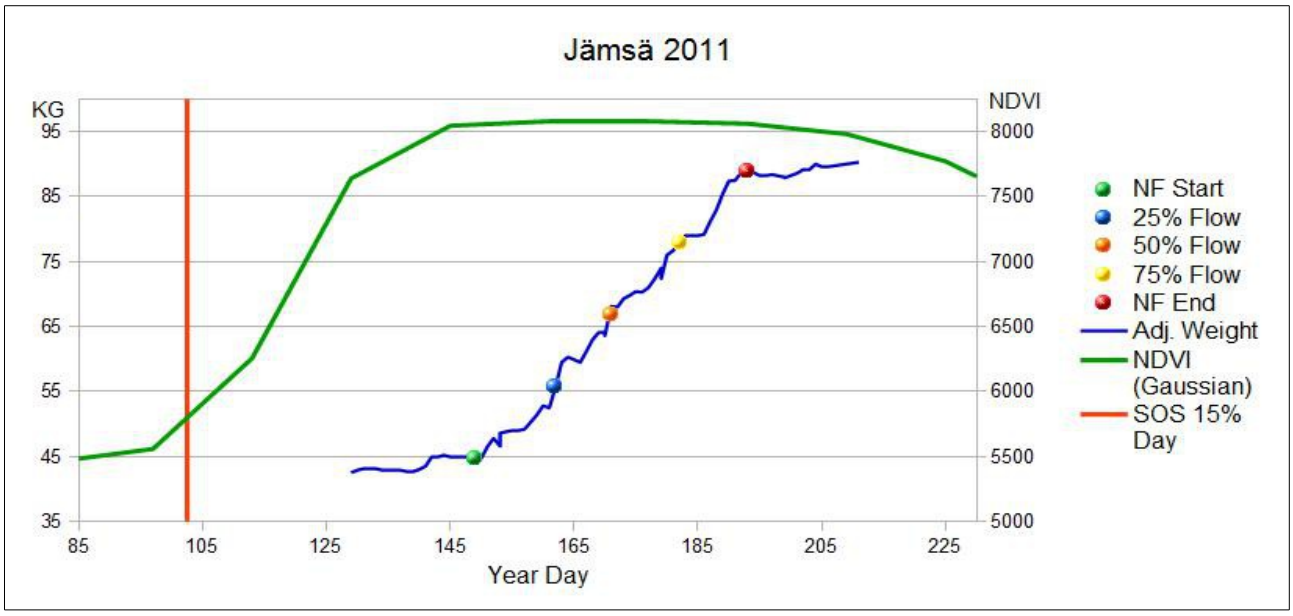


*Figure 10: Finish example of Gaussian smoothed NDVI and scale-hive data*

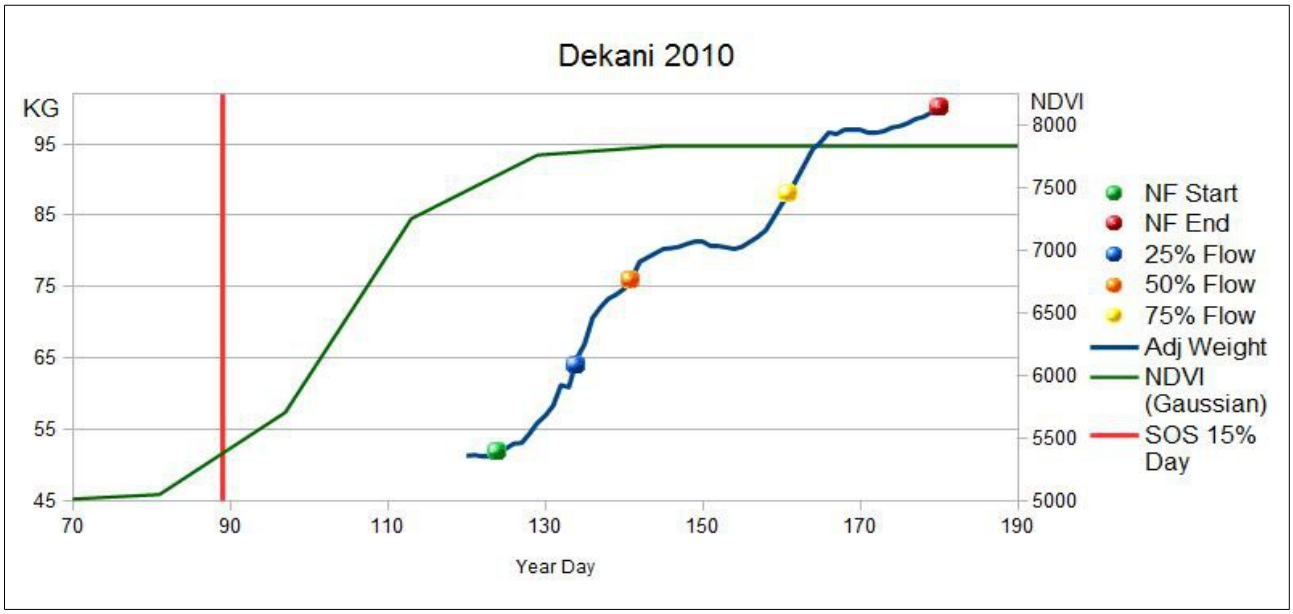


*Figure 11: Slovene example of Gaussian smoothed NDVI and scale-hive data*

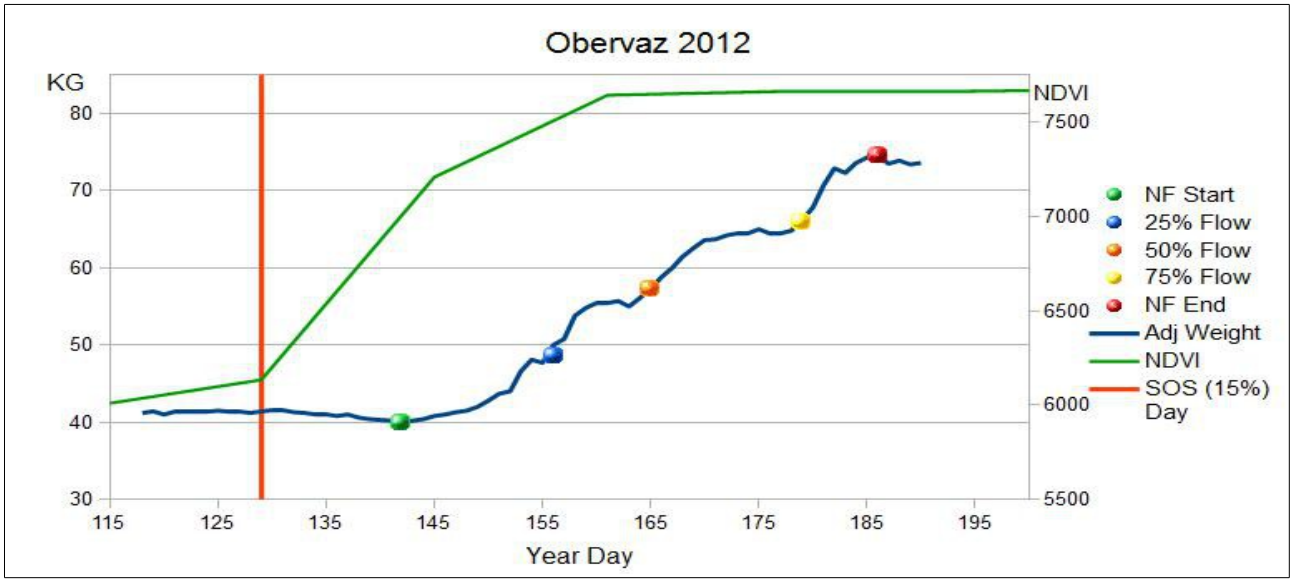


*Figure 12: Swiss example of Gaussian smoothed NDVI and scale-hive data*

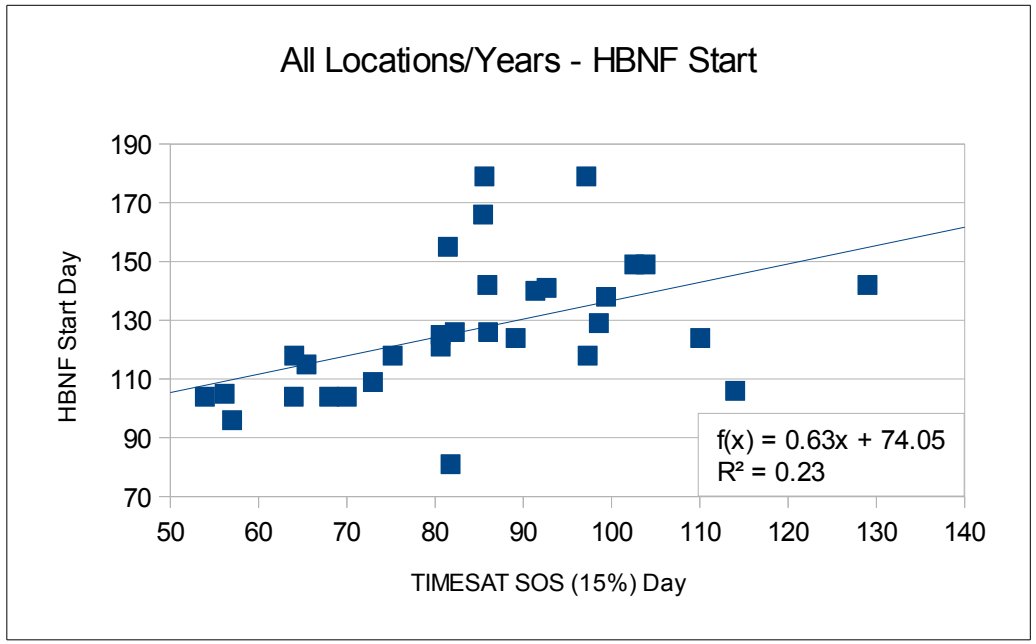


*Figure 13: All Locations/Years – HBNF Start, n=31*

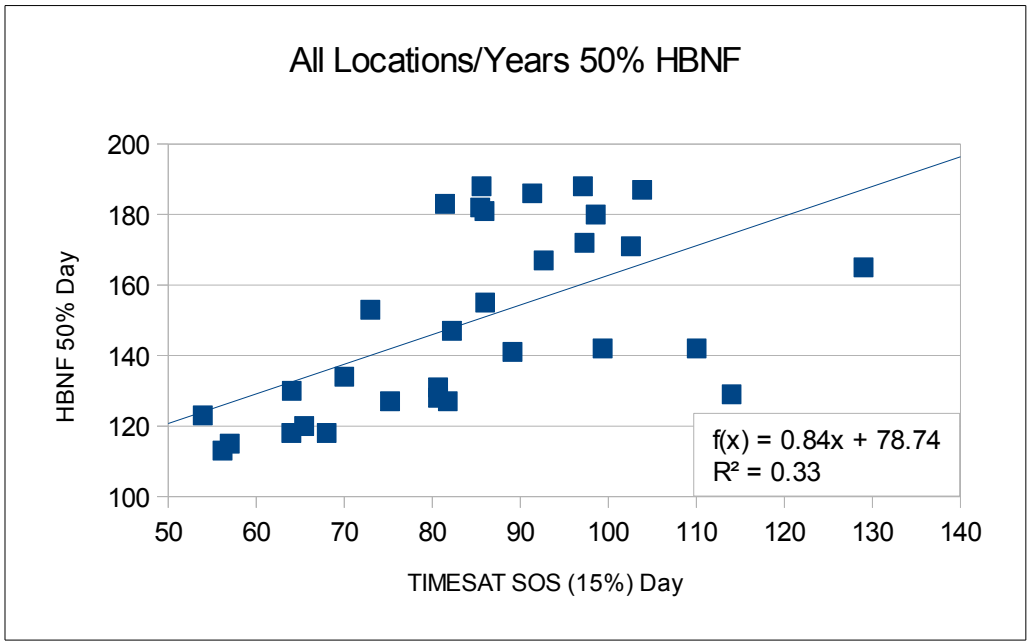


*Figure 14: All Locations/Years – HBNF 50%, n=31*

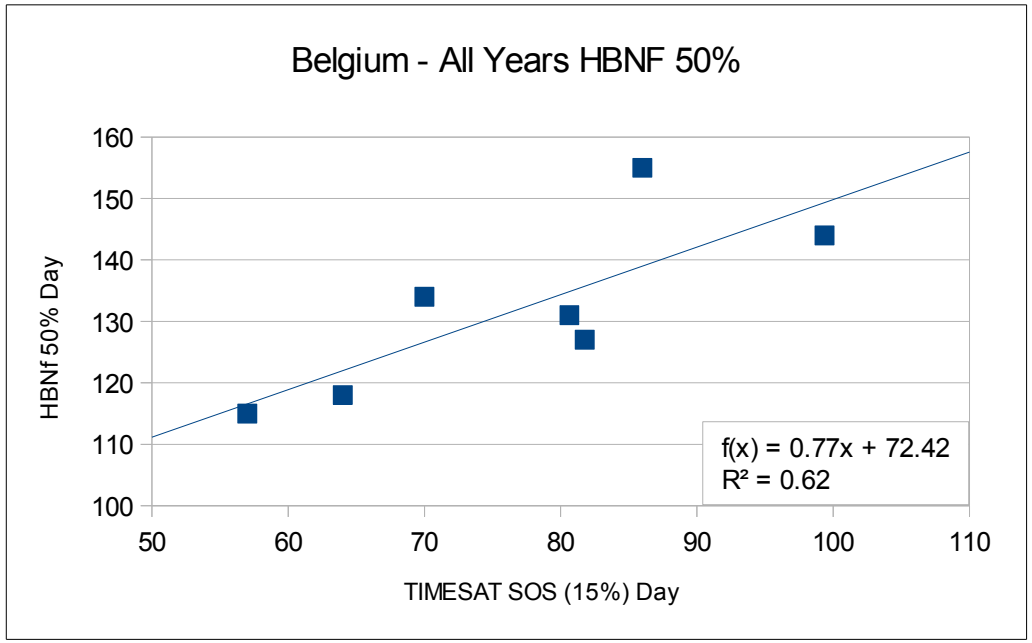


*Figure 15: Belgium – All Years HBNF 50%, n= 7*

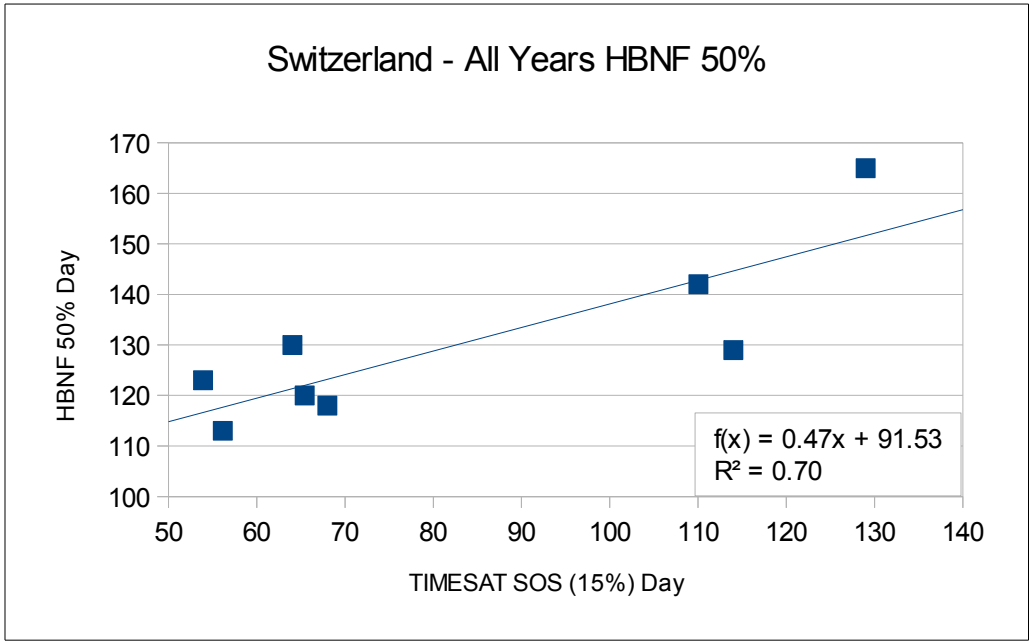


*Figure 16: Switzerland – All Years HBNF 50%, n=8*

### 4.3 TWO SCENARIOS

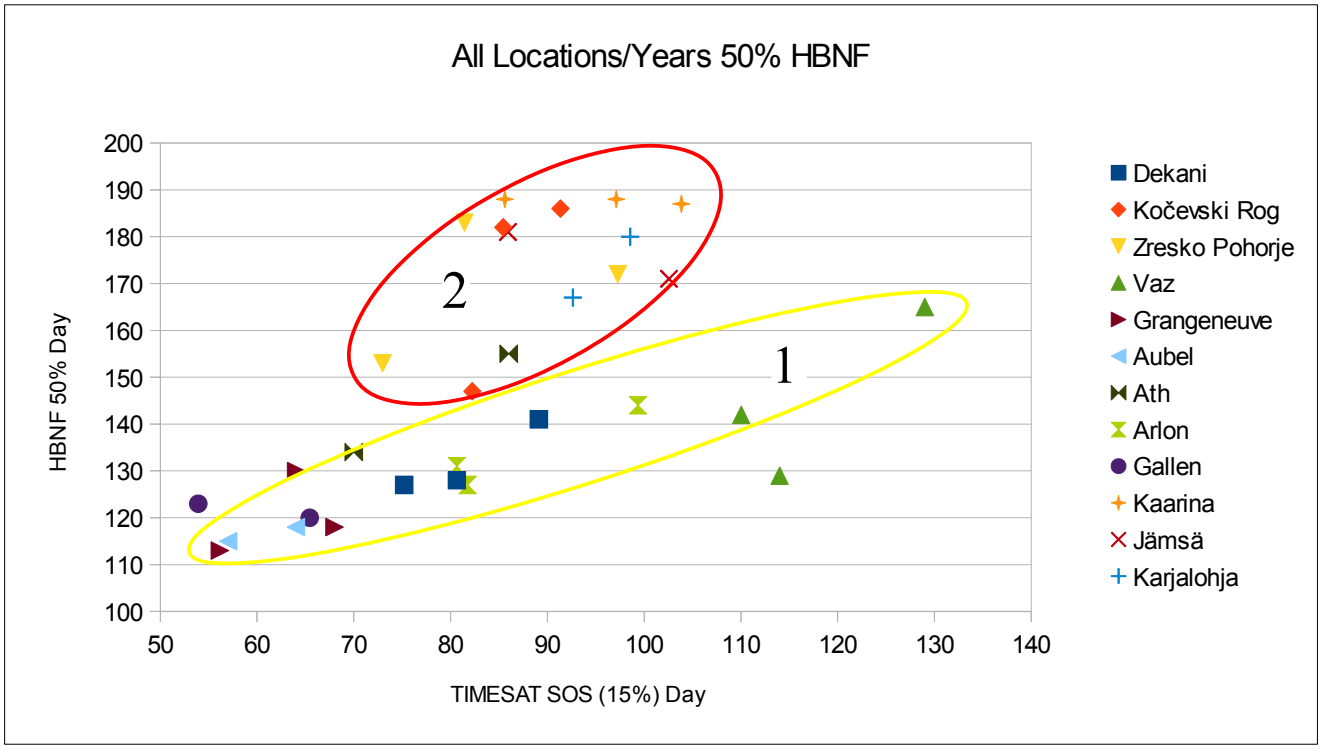


*Figure 17: All locations/years shown by location. The lower group, circled in yellow is deemed scenario 1 while the upper group, circled in red, is scenario 2.*

Figure 17 shows scale-hives by location with two point clouds: a lower group (1) generally following a linear trend beneath an upper block (2). The scale-hives are divided evenly and are seen by DMEER in table 5.

*Table 5: Hive locations by scenario*

| Scenario | Location | Country | DMEER Zone |
|---|---|---|---|
| 1 | Aubel | Belgium | Southern Temperate Atlantic |
| | Arlon | Belgium | Western European Broadleaf |
| | Dekani | Slovenia | Illyrian Deciduous Forests |
| | Grangeneuve | Switzerland | Western European Broadleaf |
| | St. Gallen | Switzerland | Western European Broadleaf |
| | Vaz | Switzerland | Alps Conifer and mixed forests |
| 2 | Ath | Belgium | Southern Temperate Atlantic |
| | Kaarina | Finland | Sarmatic Mixed Forests |
| | Jämsä | Finland | Scandinavian and Russian taiga |
| | Karjalohja | Finland | Scandinavian and Russian taiga |
| | Kočevski Rog | Slovenia | Pannonian Mixed Forests |
| | Zreško Pohorrje | Slovenia | Alps Conifer and mixed forests |

The first scenario contained the hives from Switzerland, one Slovene and two from Belgium. All hives in DMEER zone Western European Broadleaf (WEB) are in scenario 1. Looking at the locations in Figure 18, it's possible to see that all locations in the first scenario are in a spatially continuous region, mainly consisting of the DMEER WEB and Alps Conifer and Mixed Forests (ACMF).

The second scenario contained two locations from Slovenia, all three hives from Finland and one Belgian hive. This Belgian hive straddled the line between the two scenarios in Figure 17, but was included in the second due to its DMEER zone and geographical location outside the contiguous scenario 1 area.

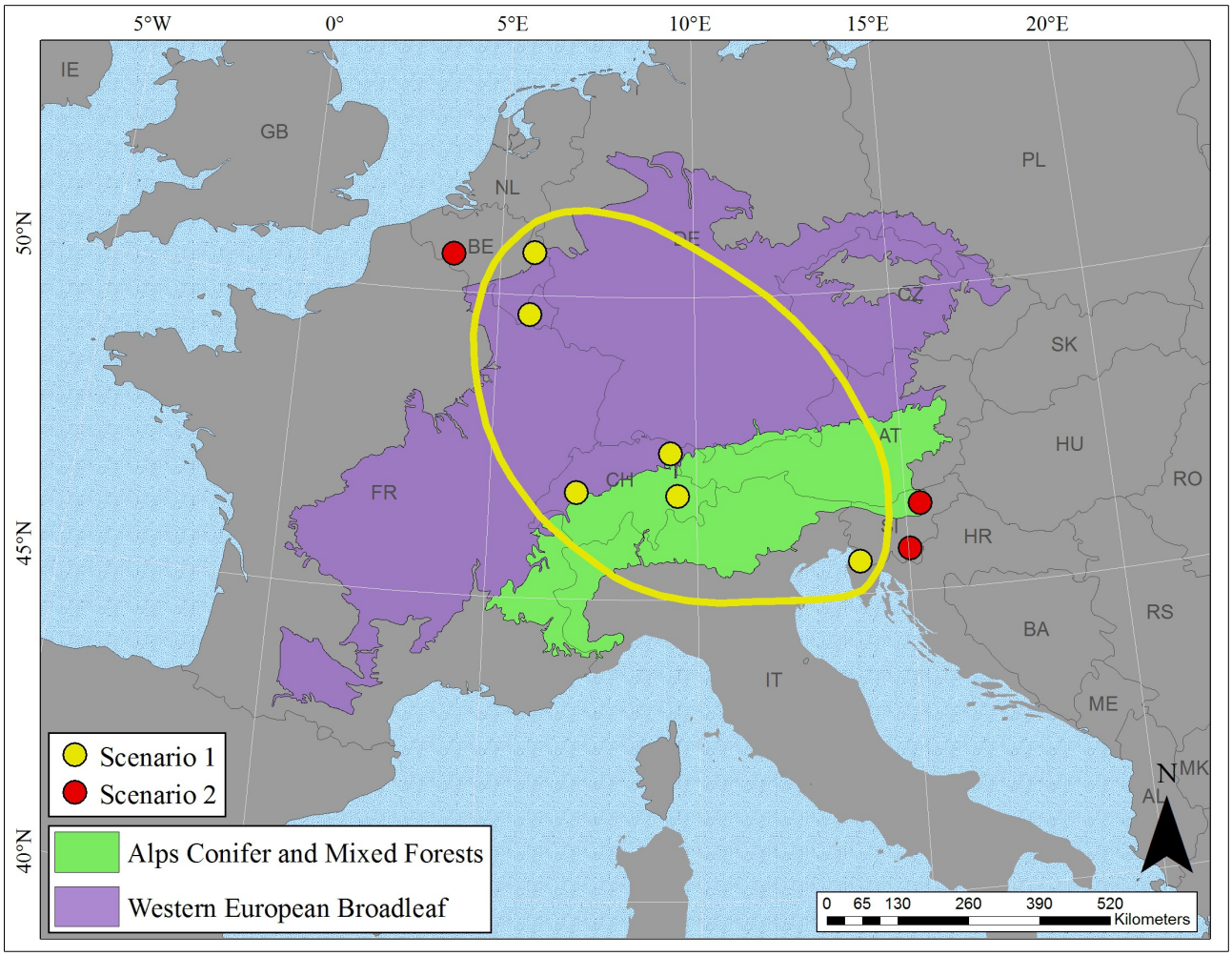


*Figure 18: Hive locations by scenarios in DMEER. Yellow polygon denotes contiguous area.*

When separated, the correlation for SOS and HBNF metrics become much stronger for the first scenario, while remaining weak for the second (Figures 21-22). The HBNF start continues to have a weak relationship (Figure 19) but the strongest correlation is found with HBNF 50% first scenario (Figure 20, $R^2 = 0.73$).

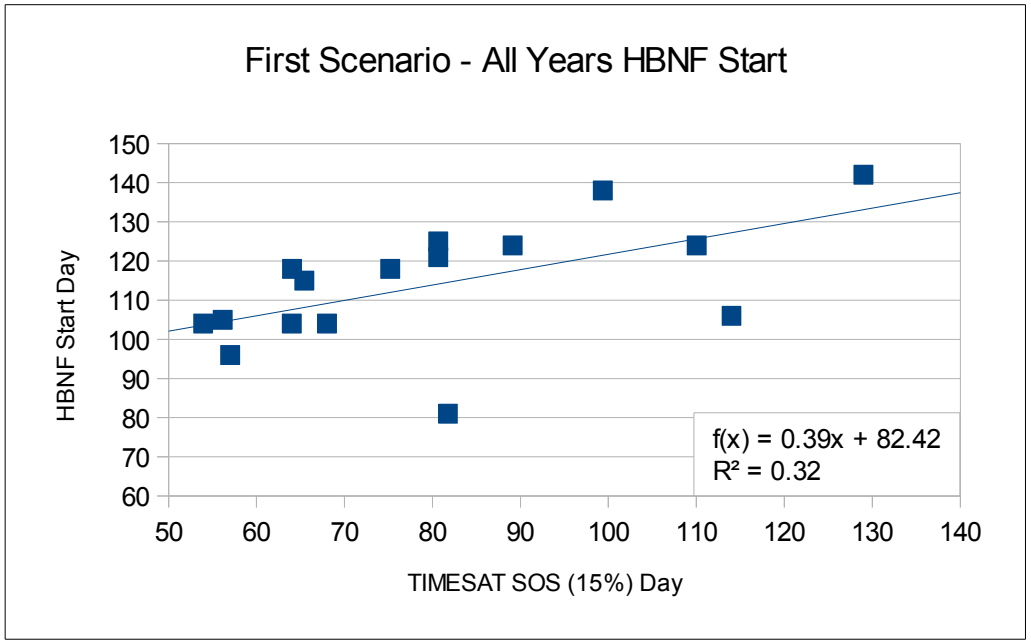


*Figure 19: First Scenario – All Years HBNF Start, n=16*

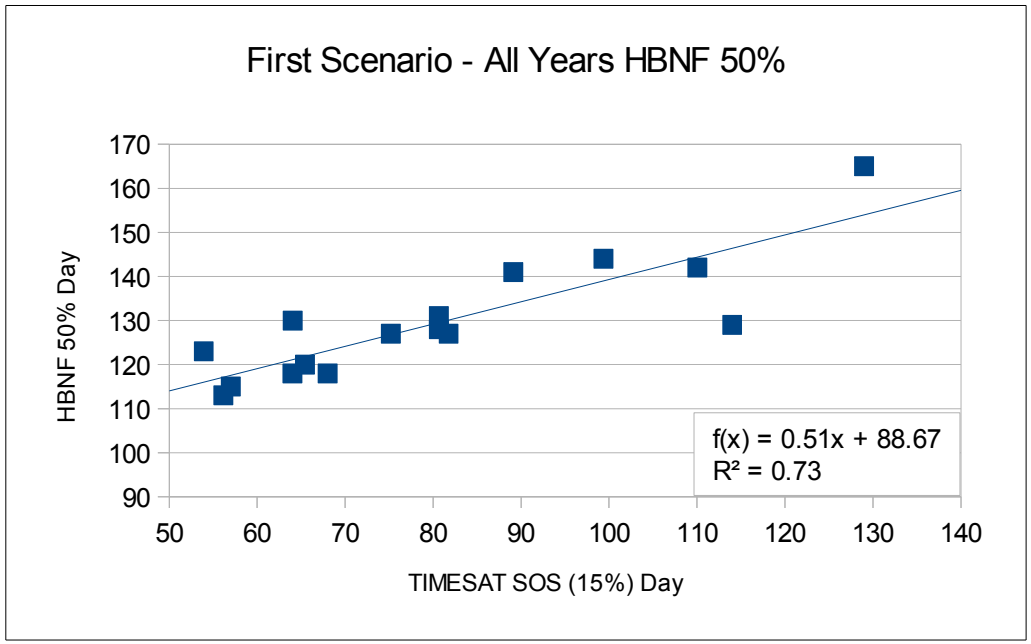


*Figure 20: First Scenario – All Years HBNF 50%, n=16*

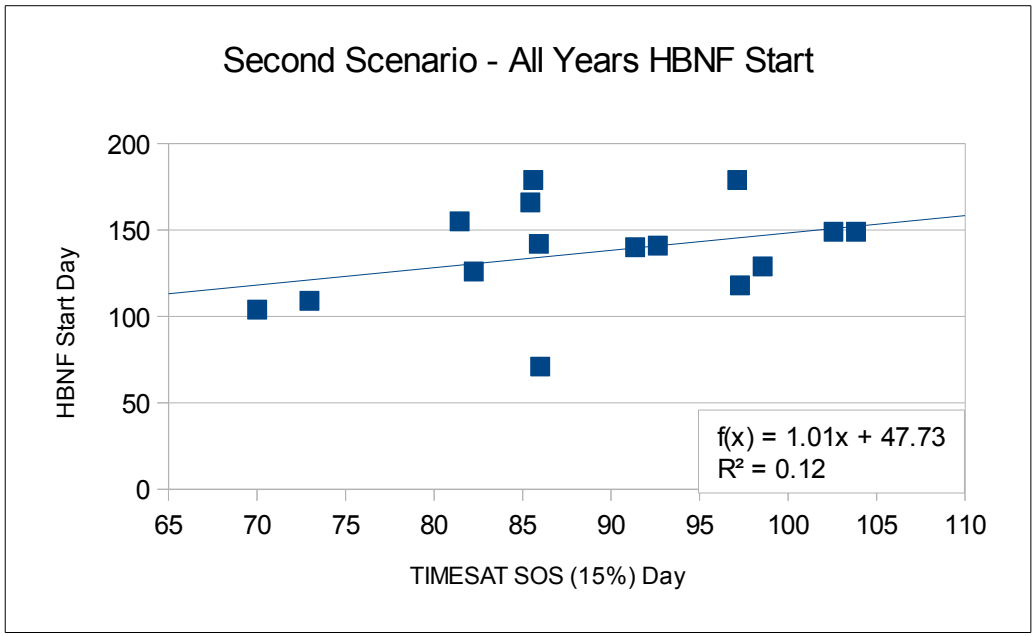


*Figure 21: Second Scenario – All Years HBNF Start, n=15*

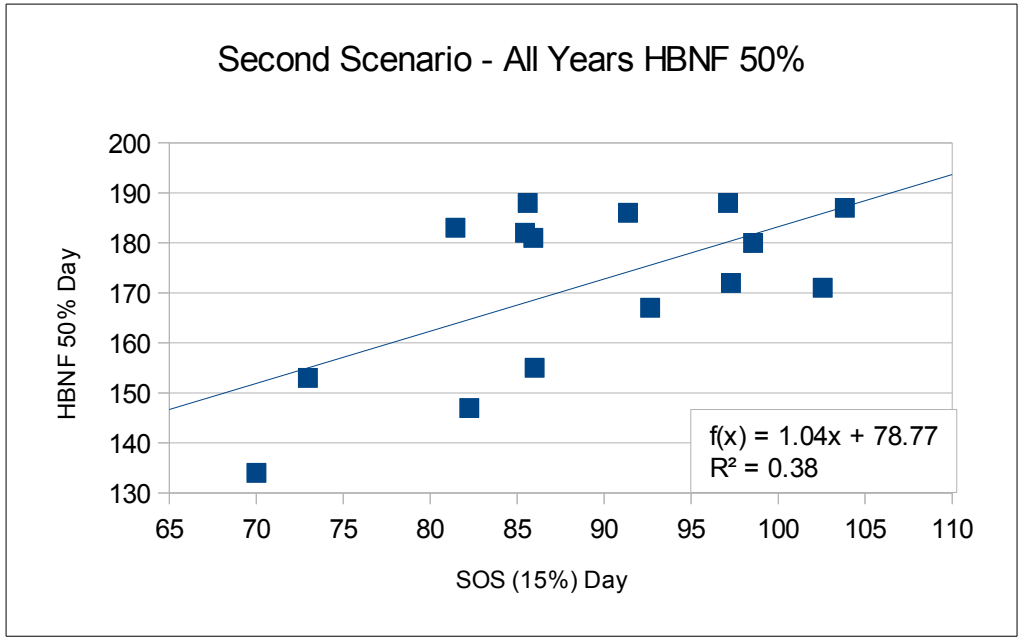


*Figure 22: Second Scenario – All Years HBNF 50%*

## 5. DISCUSSION

HBNFs are highly diverse and vary greatly between country, location and season. Nectar secretion rates relate to environmental factors and this can be partly be seen in the continental geography. Belgium has early flows due to the temperate climate while Finland's occur much later. But the microgeography is probably more effecting, as HBNFs can differ between years at the same location. For example, the 2011 NF start in Arlon began 50 days earlier than in 2010, but ended at a similar date, meaning the duration in 2011 was 40 days longer. For Vaz, 2009 and 2011 had similar NF durations, but in 2011 the NF shifted 3 weeks earlier.

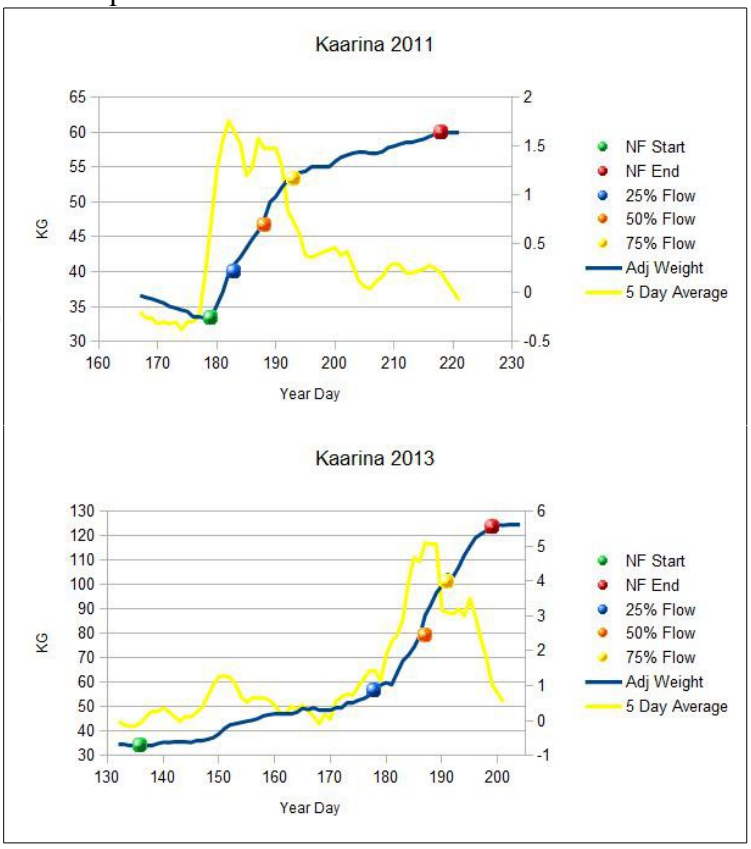


*Figure 23: HBNF metrics of Kaarina 2011 and 2013, an example of two different HBNF curvatures from the same location*

When compared to NDVI SOS, the mid-point of the HBNF showed the strongest correlation. This affirms the research of Esaias (2011), who found a similar result in the tree-dominated Northeastern United States. The HBNF start day is a less consistent metric likely because it is the edge of the distribution, which can be susceptible to compounding effects. HBNFs are variable in shape and timing (Figure 23) due to the complex underpinnings of nectar production in plants, the factors of which are many (Blomstedt, 2014: Section 2.5). However, the aggregate of flowers, which may be what the HBNF 50% days represents, appears to be a more stable measure of NFs, and therefore has a more consistent relationship with the NDVI SOS.

The spatially continuous area (scenario 1) in central Europe showed the strongest correlation between NDVI and HBNF. This area coincides with the DMEER WEB and ACMF, but this classification should not be used definitively. Zreško Pohorje did not fit the linear pattern of scenario 1 and lies in ACMF region. However it is near (15 km) from the border with Pannonian Mixed Forests (Figure 2). Similarly, Aubel is in Southern Temperate Atlantic and fits in scenario 1, but is only 15 km from WEB (Figure 3). Ath is also in Southern Temperate Atlantic, but further towards the sea, and did not belong in scenario 1. As there was no suitable resource mapping melliferous flowers in Europe (Blomstedt, 2014: Section 6.5), DMEER zones were used as a general guideline of vegetation homogeneity and the borders were considered fuzzy.

Scenario 2 included hives located in Finland, Slovenia and Belgium. These hives were

characterized by a later 50% HBNF day and had no notable correlation with SOS. One consideration is that in certain types of land cover the spring NDVI measurements may error due to the difference between understory and canopy greenness. However the hives in scenario 2 also generally had a much longer NF duration (Table 6), causing them to separate from the linear pattern in scenario 1. It is possible that the HBNFs in scenario 2 either have only a single, long NF or multiple flows combined, while scenario 1 had a spring HBNF separate from the summer/autumn flow.

*Table 6: NF Duration*

| NF Duration (mean) | |
|---|---|
| Scenario 1 | 33 |
| Scenario 2 | 53 |

The data was analysed annually to see if certain years had better correlation due to climatic factors. There does not seem to be the case, for 2011 showed a $R^2$ similar to the entire dataset. The data was also analysed by nation to account for disparate sources – each country may have different methods for managing the hives or collecting which could possibly effect the HNBF metrics. Belgium and Switzerland showed the strongest relationships for HBNF 50% day (Figures 13-14, $R^2$ = 0.62 and 0.70, respectively) while Finland and Slovenia had weak statistics. However, this is aligned with the scenarios, as the Swiss and Belgian hives are mainly within the same DMEER regions.

It's interesting to note the elevation of the hives when looking at Figure 17. The three points with later SOS days are from the town of Obervaz, 1162 m elevation. However Zresko Pohorje in Slovenia is equally high (1143m) but does not have nearly the same late SOS. The hives at lower elevation, which in this case are closest to the sea, do not follow the same pattern. Dekani is 8 kilometres from the sea and only 65m in elevation. Though it is in the DMEER "Illyrian deciduous forests," it still follows a linear pattern and lies within the spatially contiguous zone.

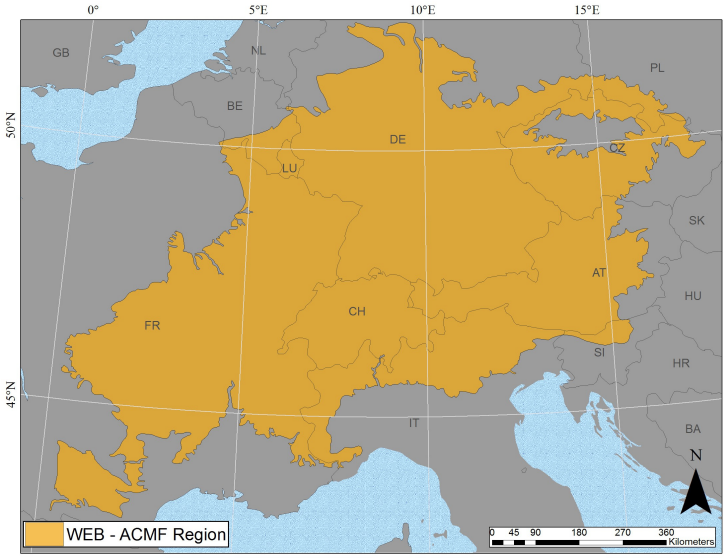


*Figure 24: Combination of DMEER Western European Broadleaf and Alps Conifer and Mixed Forests*

With HBNF correlated to the NDVI SOS in certain ecoregions, it can then be related to long-term climate models. A number of studies have investigated NDVI growing seasons in the Northern Hemisphere, with most purporting an advancing spring and delayed end of season (as reviewed in Jeong et al., 2011). Stöckli and Vidale (2004) found that from 1982-2001 there has been a general shift to earlier phenological phases by -0.54 days per year, totalling -10.8 days over 20 years. Figure 25 shows the spatial pattern of NDVI change on the continent, and their research claimed an especially significant statistic for Central Europe. Though HBNF start dates are more variable, it is possible to infer that the mid-point of

HBNFs in this region are advancing at a similar rate of a half a day per annum.

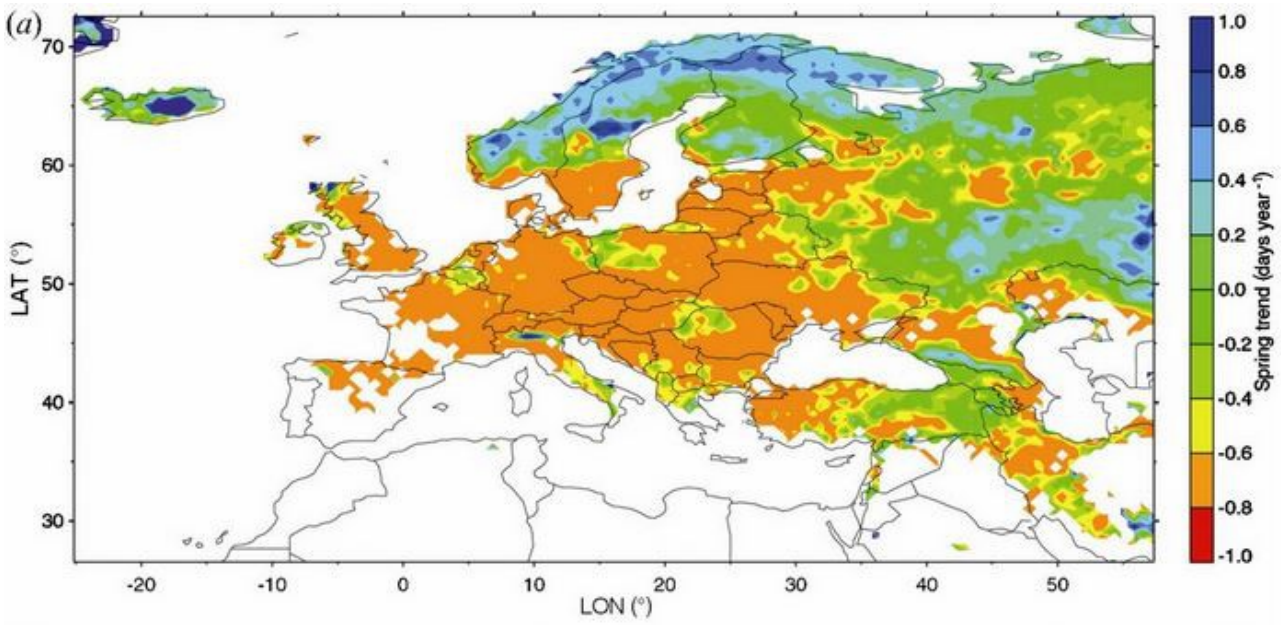


*Figure 25: Advance in NDVI derived SOS from 1982-2001. From Stöckli and Vidale, (2004)*

Several caveats must be taken into account for this research. First, this is a very general look at nectar flows, without taking into consideration plant types at each location. Nectar secretion is a very complex process, with each species, population and individual plant affected in different ways. As is well known to beekeepers, some years a nectar flow may fail completely, forcing them to feed their hives supplemental sugar. Several scale-hives considered for use in this research showed seasons where there was a small nectar flow, but overall a net loss. In other years these sites had large gains. Removing the sites with failed nectar flows distorted the data towards a stronger correlation. Further limitations include irregularity in scale-hive management, temporally coarse MODIS data and the weather (Blomstedt, 2014: Section 6).

## 6. CONCLUSION

This research has found a modest link between NDVI-derived SOS and the mid-point of the HBNF in a region of Central Europe. This is similar to what was found by Esaias (2011), both statistically and ecologically. The temperate Northeastern USA is connatural to Central Europe, and the rapid growth of NDVI can act as a provocation for nectar production for both regions. HBNF start was not influenced by the SOS date, likely due to the complexities of microclimates and temperature on nectar production in the early spring. The midpoint of the NF had the strongest correlation and this reflects the bulk of flowers. The relationship did not seem to vary by year or by country. However the countries which showed the strongest relationships also fell within the same DMEER zones.

This research only looks at a handful of scale-hive data points spread out over great distances. While the results are interesting, the small number of data points cannot be accepted as

conclusive and this research can be seen as a step towards further study. By looking at more seasons and locations of scale-hive data it will be possible to better understand European HBNFs. Additionally, only the spring season was considered in this research. The summer and autumn flows are also of interest and can be studied further. Only recently, with the rise of electronic scales and data-loggers, has scale-hive data been collected at this precision and scope. Many other scale-hives are available for use, but require labour for their cleansing and homogenization. Only in the closing stages of this research project was it known that Germany, Denmark and Sweden also have scale networks. In theory, it is possible to create a continental scale-hive network and, using interpolation techniques (Blomstedt 2014: Section 5), the HBNF can be monitored in real-time. Establishing and maintaining scale-hives is an important step, as a record of HBNF is the best way to understand their change.

## 7. DATA CITATION

### 7.1 MODIS

NDVI – MOD13Q1
LST – MOD11A2
Oak Ridge National Laboratory Distributed Active Archive Center (ORNL DAAC). 2012. MODIS subsetted land products, Collection 5. Available on-line [http://daac.ornl.gov/MODIS/modis.html] from ORNL DAAC, Oak Ridge, Tennessee, U.S.A. Accessed March 1st, 2014.

### 7.2 SCALE-HIVE DATA

Finland
Ari Seppälä
Finnish Beekeepers Association
MTT Agrifood Research Finland
Seppo Korpela
Sakari Raiskio
http://koti.tnnet.fi/web144/vaakapesa/selaa.php
Accessed 19th March 2014

Slovenia
Jure Justinek
Čebelarske zveze Slovenije
https://ecebelar.czs.si
Accessed 30th January 2014

Switzerland
René Zumsteg
Verein Deutschschweizerischer Und Rätoromanischer Bienenfreunde
http://www.vdrb.ch/service/waagvlker.html
Accessed 15th March 2014

Belgium
Centre Apicole de Recherche et Information
http://www.cari.be/balances/
Accessed 3rd February 2014

### 7.3 DMEER

Digital Map of European Ecological Regions (DMEER), Version 2000/2005
http://www.eea.europa.eu/data-and-maps/figures/ds_resolveuid/D9AD8691-4E65-4596-8A02-454EFD46A197
Accessed 8th April 2014

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Baret, F., Guyot, G., 1991. Potentials and limits of vegetation indices for LAI and APAR assessment. Remote Sensing of Environment 35, 161–173.

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# Mapping The Phenology of European Honey Bee Nectar Flows

## Part II-A: Technical Report

## ii. TABLE OF CONTENTS

## iii. LIST OF ABREVIATIONS AND ACRONYMS

AVHRR – Advanced Very High Resolution Radiometer

BRDF – Bidirectional Reflectance Distribution Function

DMEER – Digital Maps of European Ecological Regions

EVI – Enhanced Vegetation Index

GIS – Geographical Information Science

HBNF – Honey Bee Nectar Flow

HDF – Hierarchical Data Format

LAI – Leaf Area Index

LSP – Land Surface Phenology

LST – Land Surface Temperature

MLDC – MODIS Land Cover Dynamics Algorithm

MODIS – Moderate Resolution Imaging Spectroradiometer

MVC – Maximum Value Composite

NASA – National Aeronautics and Space Administration

NBAR – Nadir BRDF-Adjusted Reflectance

NF – Nectar Flow

QA – Quality Assurance

SDS – Scientific Data Set

SOS – Start of Season

VI – Vegetation Index

## iv. LIST OF FIGURES AND TABLES

## 1. INTRODUCTION

This technical report supplements the Research Paper (Blomstedt, 2014) by offering a further literature review, describing the methods used in greater depth, detailing unsuccessful approaches, addressing other research questions, and discussing the study limitations.

## 2. FURTHER LITERATURE REVIEW

### 2.1 BEEKEEPING

European honey bees (*Apis mellifera*) have been managed by humans for several millennial, with the first evidence of beekeeping found in the Mediterranean area (Crane, 2013). Bees are generally kept in order to harvest hive products like honey, wax and propolis, but they are also known for pollinating crops. In the past decade both American and European countries have reported high rates of disorders affecting their honey bee colonies (Haubruge et al., 2006; vanEngelsdorp and Meixner, 2010). The most recent survey from 2012-13 showed that many Northern European countries suffered colony losses greater than 20% (Chauzat et al., 2014). Researchers have been unable to pin down a single cause for declining bee health and instead it is likely a combination of factors including poor management practices, parasites and diseases, pesticides, climate and nutrition (vanEngelsdorp and Meixner, 2010).

### 2.2 BEEKEEPING AND GIS

Although honey bees are influenced by their environment, few studies have incorporated honey bee data into GIS for the purposes of gauging these spatial relationships (Rogers and Staub, 2013). GIS has been utilized more extensively to study solitary bee populations in relation to changing land use and climate (e.g. Kremen et al., 2002; Watson et al., 2011; Giannini et al., 2012). For honey bees, GIS and remote sensing have been employed in the prediction of nests for the Asiatic giant honey bee (*Apis dorsata*) in Malaysia (Saberioon, 2010) as well as the spatial distribution of their forage (Ibrahim et al., 2012). GIS has also been used to predict forage suitability and prime beekeeping locations in the Philippines. (Estoque and Murayama, 2011), North Eastern Italy (Berardinelli and Vedova, 2004), Malaysia (Maris et al., 2008), Saudi Arabia (Abou-Shaara et al., 2013) and Belgium (Janssens, 2006). Finally, GIS has been incorporated by Naug (2009) to study the relationship between habitat loss and honeybee colony collapses, and by Henry et. al. (2012) to look at floral scheme efficiency.

## 2.3 HONEY BEES

The European bee is one of seven bee species in the *Apis* genus and the only native to Europe. Regional climates have caused the evolution of several subspecies of *Apis mellifera* on the continent, including *Apis mellifera mellifera* (German dark bees), *Apis mellifera ligustica* (Italian bees), *Apis mellifera carnica* (Carniolian bees) and *Apis mellifera caucasica* (Caucasian bees) (Ruttner, 1975). It is a eusocial insect, living in large colonies with a complex social system consisting of three castes: queen, worker and drone. Each colony normally has a single queen who is the mother of all the inhabitants. After hatching and a brief mating flight, the queen spends the remainder of her life laying eggs inside the hive. Workers are unfertilized females and make up the majority (~90%) of the population. As their name suggests, they perform virtually all the tasks required by the colony, including cleaning, rearing larvae, defending from attackers and foraging. Drones are the male and do little else besides congregate outside the hive and attempt to mate with virgin queens on summer afternoons.

Hive population varies by season, with growth is usually at or near the maximum in the spring (Winston, 1991). In an annual period a colony will rear some 150,000 bees, but will overwinter with only a few thousand. Colonies need to collect 120 kg of nectar and 20 kg of pollen annually to survive (Seeley, 1985). Nectar is processed and ripened into honey; a hygroscopic, antibacterial liquid that, with a water content of 18%, is resistant to yeasts and fermentation. Bees also consume honey to secret wax, with approximately 8 kg of honey needed to make 1 kg of wax (Whitcomb Jr, 1946). The wax is used to build the comb structure on which all in-nest activities occur. With the average load of nectar around 10 mg, a hive will make almost 4 million trips for nectar and one million for pollen per annum (Winston, 1991). In strong colonies and under ideal conditions, workers can make up to 163,000 trips daily (Gary, 1967). Yet many feral colonies barely collect enough resources and many starve to death every winter (Seeley, 1985).

## 2.4 FORAGING

To gather food, honey bees must leave their hive and enter the surrounding environment. Bees have been reported to forage at temperatures between 5º and 45º C (Heinrich, 1979; Cooper et al., 1985; Spangler, 1992) but foraging generally does not begin until temperatures reach 12º-14º C (Winston, 1991). Relationships between wind, rain and foraging show decreasing foraging intensity resulting from higher winds and heavier rainfall (Ribbands, 1953). Furthermore, light intensity and global solar radiation values are positively correlated with flight departures (Burrill and Dietz, 1981).

The foraging range of a honey bee colony depends on the availability of resources. Flying for nectar or pollen requires energy expenditure and foragers will not travel long distances if unnecessary. In agricultural areas, the median foraging radius of honey bee colonies is only a few hundred meters (Ribbands, 1953; Michener, 1974) but in a deciduous forest in New York State, colonies foraged over a large radius, from 0.5 to 10 km, with a mean of 2.3km (Visscher and Seeley, 1982). In central Germany, Steffan-Dewenter and Kuhn (2003) found a mean of 1.5 km with a range of up to 10 km. Karl von Frisch, the original reporter of the bee dance language, discovered a scout bee could report sources up to 13.5 km away (Von Frisch, 1967). The foraging distance varies greatly on the time of year, with bees often forced to fly much greater distances in the summer due to the scarcity of nectar (Beekman and Ratnieks, 2000; Beekman et al., 2004; Couvillon et al., 2014). The range is also influenced by the particular hive, as foraging distances have been shown to differ significantly between matched colonies (Waddington et al., 1994). Visscher and Seeley (1982) found the 95$^{th}$ percentile of foragers was at 6km, a radius encircling more than 100 km$^{2}$. Except in extreme cases, such as large-scale monocrop agriculture, there will be an array of floral sources within this area.

**2.5 NECTAR PRODUCTION**

Nectar is a sugar-rich liquid produced by flowers as a part of plant-animal mutualism. It is the food for an enormous variety of insects, a tenth of all bird species and also can act as an energy drink for some larger animals. Nectar composition varies widely, quantitatively more than qualitatively, presumably because it is produced to reward different kinds of animals (Faegri and Van der Pijl, 1966). Its basic constituents are water, ions, carbohydrates, amino acids, low molecular weight proteins, enzymes and antioxidants to maintain homoeostasis (Carter and Thornburg, 2004).

Nectar secretion is a complex process based on the genetics of the plant as well as many facets of the environment. This means nectar secretion may vary not only between species, but between population, individual or even flower. Temperature is the environmental variable most often cited as related to nectar secretion rate (Nicolson et al., 2007). Secretion does not start below a certain temperature, the critical threshold according to the species, and then tends to increase alongside temperature (Fahn, 1949; Shuel, 1952; Corbet, 1990; Jakobsen and Kritjánsson, 1994). However it also reported to slow with increasing temperature in certain plants (Freeman and Head, 1990; Jakobsen and Kritjánsson, 1994). The optimum range of temperature for nectar secretion is known for only a few species (Jakobsen and Kritjánsson, 1994 and references therein). Water availability is also considered a factor in the regulation of nectar secretion rate (Wyatt et al., 1992)

as are soil nutrients (Shuel, 1957), ambient humidity (Corbet et al., 1979) and the use of fertilizers (Fahn, 1949; Shuel, 1992). Visits by insects or artificial withdrawal of nectar are also thought to stimulate secretion (Heinrich, 1975; Real and Rathcke, 1991).

Nectar is not secreted at a constant rate. For most plants there is not only a difference between night and day, but a characteristic rhythm of secretion throughout the 24 hours (Cruden et al., 1983). Due to higher humidity, nectar secretion during the night usually contains more water than in the day; for certain plants (*Borago, Teucrium*) the diurnal rate of nectar secretion may remain constant while the sugar content varies, while for others (*Lythrum, Salvia*) the quantity may fluctuate while the sugar concentration remains the same (Crane, 1975). For many plants the optimal time for nectar secretion (maximum quantity and sugar content) is during the morning, and the foraging bees will adjust to the daily plant rhythm. Their visits to a certain species of flowers reach a maximum in the peak period of nectar secretion – i.e. when the flowers offer the greatest quantity of the most highly concentrate nectar (Michener, 1974). When a plant has two separate peaks periods, the curve plotted for bee visits will also show two peaks.

## 2.6 PHENOLOGY

Phenology, which is derived from the Greek word phaino meaning to show or to appear, is the study of recurring plant and animal life cycle stages, especially their timing and relationships with weather and climate (Schwartz, 2003). Sprouting and flowering of plants in the spring, bud burst, colour changes of leaves in the fall, bird migration and nesting, insect hatching and animal hibernation are all examples of phenological events (Dube et al., 1984). These events are genetically predetermined but also strongly modulated by climatic conditions, particularly temperature, day length and water availability (Schaber and Badeck, 2003; Zhang et al., 2005). Currently there is great concern over the Earth's changing climate (Walther et al., 2002; IPCC, 2007). With the past century warming 0.85º C and predicted to continue (Stocker et al., 2013), phenology is seen as an efficient method to compare records of the past to the current biotic response.

Phenological records go back to the 1730s in the UK (Sparks and Carey, 1995) and even longer in China (Hameed and Gong, 1994) and Japan (Aono and Kazui, 2008). Many European countries have records for a variety of phenological events for decades or even longer (Chmielewski, 1996). The second half of the 20$^{th}$ century showed an assortment of shifting spring phenologies, with Western and Central Europe advancing four weeks and Eastern Europe delaying by up to two weeks (Ahas et al., 2002). Spring advances have been reported for a variety of living

organisms including vertebrates (Lehikoinen et al., 2004; Thackeray et al., 2010) invertebrates (Roy and Sparks, 2000) and terrestrial plants (Menzel et al., 2006)

## 2.7 PHENOLOGY OF PLANTS

Flowering in angiosperms is an important phenological measure. Plants in temperate areas are adapted to an annual seasonal cycle with a winter dormancy period that is sensitive to temperature and light. In many cases flowering time is directly related to temperature (Sparks et al., 2000), but some species may not flower earlier as a response to increased temperatures (22% of species included by (Menzel et al., 2006)). Other potential cues for flowering initiation include photoperiodicity, precipitation, soil humidity and snow melt (Price and Waser, 1998; Inouye et al., 2003) as well as other, more peculiar stimulus (Lambrecht et al., 2007).

Plants are frequently shown to be flowering earlier compared to the past (Root et al., 2003; Parmesan, 2007) but most studies use first flowering dates describe changes in phenology (Sparks and Carey, 1995; Inouye et al., 2003; Miller-Rushing and Primack, 2008). This is often because only first flowering dates are available; it's much easier for an observer to note the date that a species first flowers rather than monitoring the progression of flowering from an entire population, which could last for weeks or even months. But first flowering lies at the edge of the flowering distribution and can be susceptible to compounding effects. Those observations may be affected by population size and sampling effort (Miller-Rushing et al., 2008).

## 2.8 PHENOLOGY OF HONEY BEES

The importance of temperature on insect phenology has been extensively demonstrated (Zhou et al., 1995; Sparks and Yates, 1997; Forister and Shapiro, 2003; Stefanescu et al., 2003). Invertebrates are perhaps the most sensitive branches of organisms to climate change (Gordo and Sanz, 2006). Insects are small and poikilothermic, therefore their thermoregulation and activity are strongly affected by weather variability. In species with a wintering larval stage, warmer years will cause adults will emerge earlier.

While not as prevalent as some other phenological databases (Sparks and Carey, 1995), beekeepers and researchers have recorded honey bee phenology. In certain areas (e.g. Slovenia) scale-hive records have been kept for over 100 years. Another phenological event is the honey bee “cleansing flight,” when bees first leave the hive to excrete the faeces stored in their gut. These flights are related to ambient temperatures (Scheifinger et al., 2005), specifically a strong negative relationship with temperature in February to April (Gordo and Sanz, 2006). Sparks (2010) reported

an advance in these cleansing flights in Poznań, Poland by over a month during the period 1985-2009. Gordo and Sanz (2006) also reported an advance of cleansing flights in Spain during 1952-2004.

Honey bees are one of the few insects that do not take an obligate diapause, meaning they spend the winter as adults in an active state. Consequently they are able to react much more quickly to the changing conditions outside the hive. This appears to make them less of a concern to the concept of a trophic collapse, however the colony may suffer from rapidly changing phenologies. Because honey bee nectar flows (HBNF) can be short and intense, the hive must be prepared with an adequate foraging force when the flowers are secreting nectar. If this comes early, when only a minimal number of foragers are available, the colony will not be able to take full advantage of the flow and subsequently not have enough food for the coming dearth.

While honey bees only have to wake from their lethargy, other species of bees spend the cold period inactive in larval form, meaning they must complete their development in response to environmental factors in the spring. The few species which have been studies show more complex responses in their spring emergence (Bosch and Kemp, 2003; Sgolastra et al., 2010). These species are more susceptible to the threat of tropic decoupling, as they are often specialist pollinators with a smaller number of plant species to forage on. These under-appreciated pollinators are often more effective than than honey bees are contribute greatly to agricultural production (Garibaldi et al., 2013).

## 2.9 START OF SEASON

Remote sensing integrates signals from land surface processes as well as reflectance from plants, so satellite-based phenology is often called land surface phenology (LSP). One sought after measure of LSP is the start of season (SOS) which is defined as the rapid sustained increase in remotely sensed greenness after the longest annual period of photosynthetic senescence (White et al., 2009). With remote sensing's ability to detect LSP at large scales, it is possible to model phenological patterns at a regional continental or global scale.

There have been many attempts to calculate SOS and other phenological metrics (Lloyd, 1990; Reed et al., 1994; Myneni et al., 1997; White et al., 1997, 2002; Zhang et al., 2003; Jönsson and Eklundh, 2004; Fisher et al., 2007; Tan et al., 2008; de Beurs and Henebry, 2010). One problem facing these methods is that an accepted definition of spring arrival does not exist. Frequently SOS, “green-up,” leaf-out and “green wave” are used interchangeably, but in reality may refer to different biological processes. White and Nemani (2003) point out a potential confusion and bias on how to

calculate phenological transition times due to the mix of methods and definitions being used.

*Table 1: A selection of SOS calculation methods: name and estimation category. From White (2009)*

| Full name | Algorithm: SOS estimate |
|---|---|
| Quadratic | Conceptual-mathematical: first composite period of growing degree accumulation best fitting the observed NDVI time series |
| NDVI 0.2 | Global threshold: NDVI exceeds 0.2 |
| NDVI 0.3 | Global threshold: NDVI exceeds 0.3 |
| Delayed Moving Average | Conceptual-mathematical: smoothed NDVI exceeds expected value of near-term historical NDVI |
| Harmonic Analyses of NDVI Time-Series – Fast Fourier Transform | Conceptual-mathematical: maximum increase on Fourier approximation of NDVI |
| TIMESAT | Conceptual-mathematical: high amplitude divergence from a multiple-model NDVI fit |
| Midpointpixel | Local threshold: NDVI exceeds locally tuned threshold; run for every pixel |
| Percent-Above-Threshold | Local threshold: NDVI exceeds locally tuned threshold; run for the group behavior of all pixels within an ecoregion |
| Gaussian | Hybrid: average date when Gaussian fit of NDVI exceeds three global thresholds |
| Midpointcluster | Local threshold: NDVI exceeds locally tuned threshold; run for time series aggregated to a cluster level |

LSP and SOS calculations have often compared poorly with field-based phenology. Schwartz and Hanes (2010) found few significant correlations between five SOS calculations at three observed sites in the eastern United States, concluding that collecting ground data at an areal scale similar to satellite data was needed. White et al. (2009) performed a comprehensive intercomparison of Advanced Very High Resolution Radiometer (AVHRR)-based SOS methods over broad regions of North America, relating them to ground phenology data, bioclimatic model predictions and cryospheric/hydrologic seasonality metrics (Table 1). Tested SOS measures found that individual methods differed from each other by ±60 days with a standard deviation of ±20. The estimates were most accurate in northern latitudes and least in arid, tropic and Mediterranean ecoregions. In a comparison with an ensemble of SOS models averaged by ecoregion from 1982–2006, TIMESAT had the least SOS day of year variability anomalies.

## 2.10 DIGITAL MAPS OF EUROPEAN ECOLOGICAL REGIONS (DMEER)

### 2.10.1 ALPS CONIFER AND MIXED FORESTS

Situated in Central Europe, the Alps conifer and mixed forests stretch 1200 kilometres across France, Italy, Germany, Austria, Slovenia and Switzerland and Liechtenstein (Figure 1). The Alps are ecologically significant region similar to the original forest cover of central and southern Europe. Some of these forests can be considered almost in a natural state. Over 4500 species of plants are found this region, 400 which are endemic.

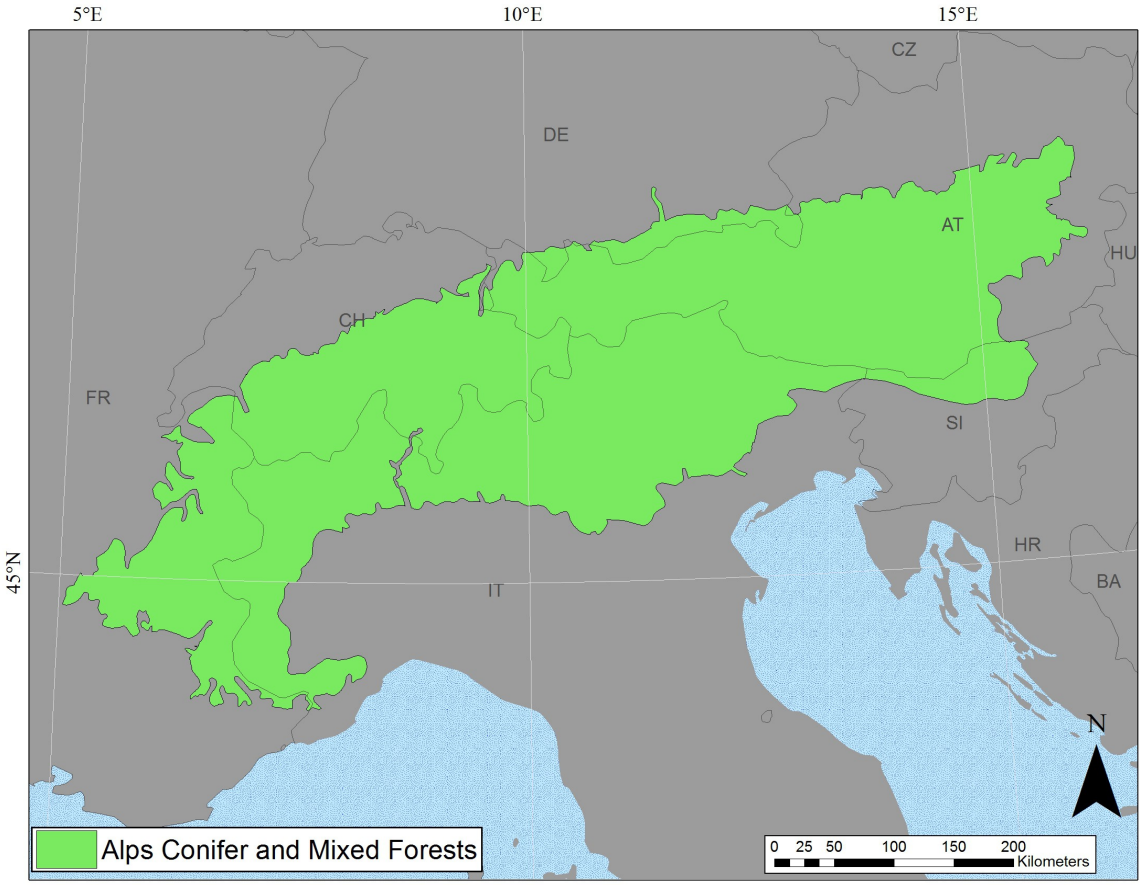



*Figure 1: Alps Conifer and Mixed Forests DMEER*

The Alps are a temperate, cool transitional zone between central and Mediterranean Europe. They can be divided into three major sections; the western is influenced by the mild and humid Atlantic air streams, the central has continental climate and the eastern region exhibits a Mediterranean climate. Three relevant ecological patterns can be identified within this mountain system – deep valleys with broad-leaved trees, evergreen trees in Mediterranean areas and mountain forests composed of mixed European Beech (*Fagus sylvatica*), Silver Fir (*Abies alba*), Norway Spruce (*Picea abies*) and others (Bohn et al., 2000). However these can be split up even further, with 200 habitat types classified throughout the mountain range (Fund and Hogan, 2014). Wildflowers present in the ecoregion are the endemic Alpine Columbine (*Aquilegia alpina*) and the

near endemic Jeweled Rocket (*Sisymbrium austriacum*); other non-endemics include Snow in Summer (*Cerastium tomentosum*) and Candle Larkspur (*Delphinium elatum*).

### 2.10.2 WESTERN EUROPEAN BROADLEAF FORESTS

Western European Broadleaf Forests are a palearctic ecoregion of approximately 492,360 km$^2$ across eastern France, southern Germany, northern Switzerland, northern Austria, part of the Czech Republic and a small area of western Poland (Figure 2). This region covers extensive lowlands, but also higher elevation such as the Alps and Ardennes. Generally these contain lowland

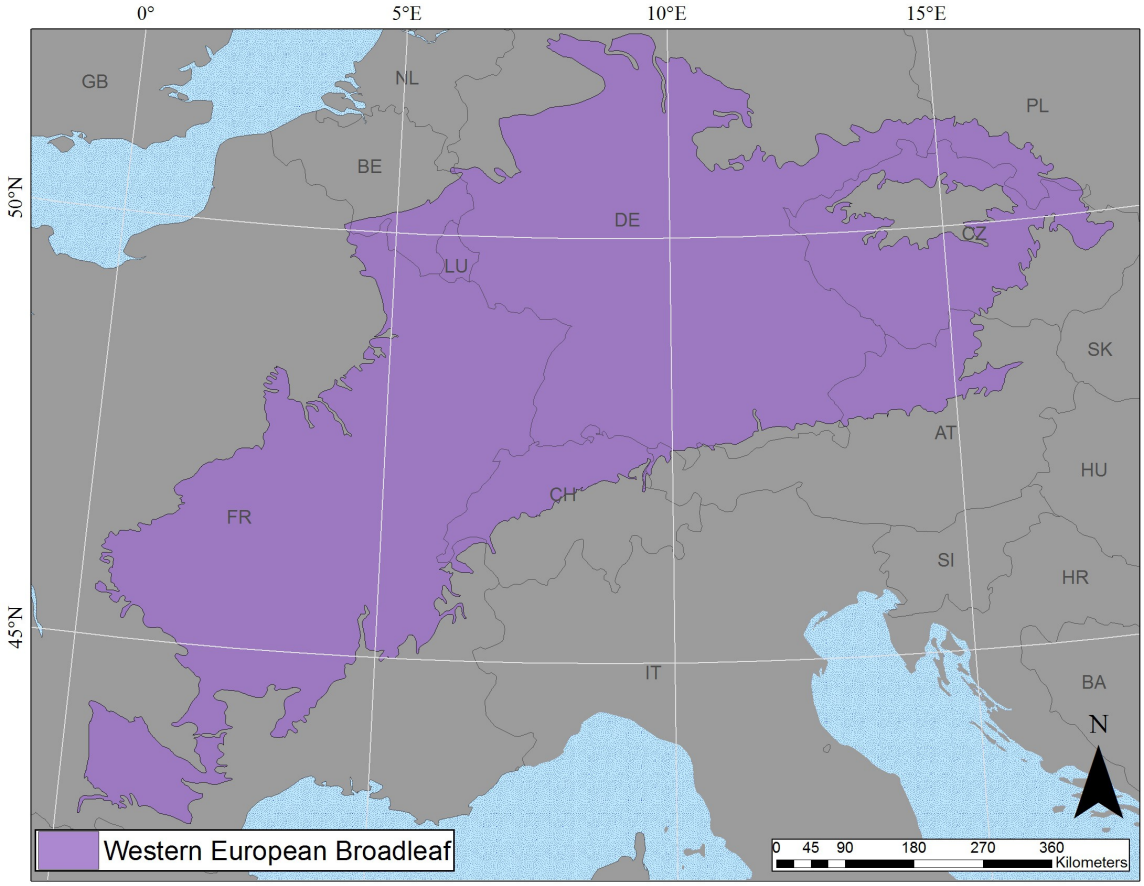



*Figure 2: Western European Broadleaf DMEER*

to altimontane beech and mixed beech forests of Western Europe, small areas of sub-Mediterranean and meso-supra-Mediterranean downy oak forests and mixed oak hornbeam forests (Bohn et al., 2000). It is classified within the biome of temperate Broadleaf and Mixed forests

This ecoregion has variety of plant assemblies, ranging from true broadleaf forests, to raised bogs and moorlands, although most of the land area has been converted to agriculture (Fund and Hogan, 2013). The main cultivated crops are corn, wheat and oats. This ecoregion holds large cities like Lyon, Nancy and Munich, and it suffers from heavy degradation due to millennia of expanding human populations.

# 3. TECHNICAL REPORT

## 3.1 MODIS METHODOLOGY

The Moderate Resolution Imaging Spectroradiometer (MODIS) is an instrument aboard NASA scientific research satellites Terra (EOS AM-1) and Aqua (EOS PM-1) designed for the long-term global remote sensing of the earth's surface and biosphere. Both satellites are at an altitude of 705 km in a near polar orbit with an inclination of 98.2 and a mean period of 98.9 minutes (Salomonson et al., 1989). They are sun-synchronous, with Terra crossing the equator at 10:30 AM, and Aqua at 1:30 PM (Barnes et al., 2002) and together cover the entire Earth's surface every 1 to 2 days. MODIS acquires data in 6 spectral bands spaced between 0.4 µm to 14.4 µm at varying spatial resolutions (2 bands at 250m, 5 bands at 500 m and 29 bands at 1km). It employs a whiskbroom scanning radiometer at a scan rate of 20.3 rpm, with a cross track swath size of 2330 km by 10 km (at nadir) (Nishihama et al., 1997). A global network of ground control points has improved the geolocation accuracy of Terra to better than 45 m and Aqua better than 60 m (Wolfe, 2006). The MODIS project offers a number of processed datasets related to the earth's surface, such as vegetation indices (VI).

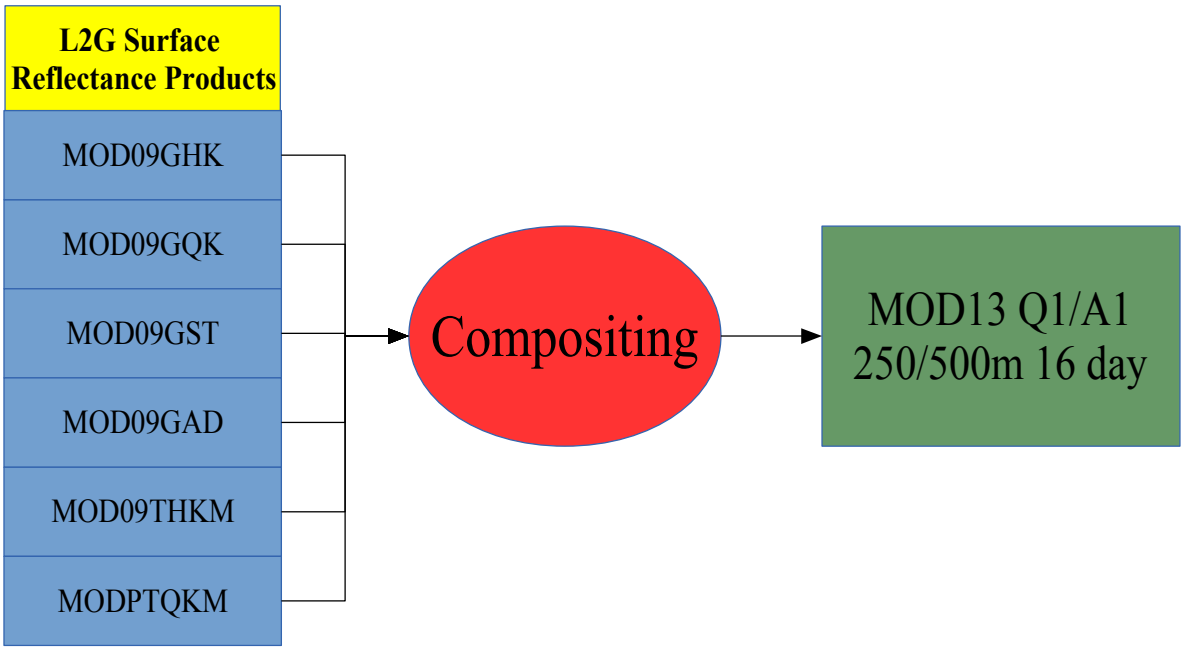



*Figure 3: Compositing method for MOD13 Q1/A1 products*

MOD13Q1 is a land product derived from data captured by the MODIS Terra satellite. The dataset began production in February 2000 and provides a tile raster VI with a resolution of 250 meters at a 16 day temporal granularity. The MOD13A1 algorithm separates all observations by their orbits and applies a filter to the data based on quality, cloud, and viewing geometry (Solano et

al., 2010). The VI algorithm operates on a per-pixel basis and requires multiple observations to generate a composited index (Figure 3). The pixels are sorted by quality; cloud contaminated and extreme off-nadir sensor views are considered low quality while cloud-free, nadir view with no residual atmospheric contamination are considered high quality. Only the high-quality cloud-free pixels are retained for compositing. Due to orbit overlap, multiple observations may exist for one day and a possible of 64 may occur in a cycle. But because of clouds and sensor spatial coverage, the number is frequengly less, with decreasing observations from polar to equatorial latitudes. The number of acceptable pixels over a 16-day compositing period is often fewer than 10, usually varying between 1-5 (Solano et al., 2010). The objective of the compositing methodology is to determine a single value per pixel from all the data retained by the filter, which is assumed to be representative for the pixel over the 16 day period.

This VI compositing algorithm includes (i) the maximum value composite (MVC), meaning each pixel is assigned the maximum value across all observations for that pixel acquired during the compositing period, and (ii) a constraint of view angle–MVC (Holben, 1986). As a result the quality of MODIS NDVI data is significantly enhanced (Huete et al., 2002). Each MODIS land surface dataset contains, along with the science and metadata, one or more quality assurance (QA) layers. These provide pixel level QA (Table 2) as well as summary statistics of certain attributes.

*Table 2: MODIS Pixel Quality Assessment*

| Rank Key | Summary QA | Description |
|---|---|---|
| -1 | Fill/No Data | Not Processed |
| 0 | Good Data | Use with confidence |
| 1 | Marginal data | Useful, but look at other QA information |
| 2 | Snow/Ice | Target covered with snow/ice |
| 3 | Cloudy | Target not visible, covered with cloud |

### 3.2 TIMESAT

A time series is a sequence of observations where adjacent measurements are dependant on time (Box et al., 2013). The value of coarse-resolution time-series NDVI data has been firmly established for monitoring vegetation (Malingreau, 1986; Reed et al., 1996; Tucker et al., 1986) and major phenological events (Reed et al., 1994; Zhang et al., 2003). TIMESAT is a program developed by Per Jönsson and Lars Eklundh for the analysis of time series of satellite sensor data (Jönsson and Eklundh, 2002, 2004). TIMESAT was originally intended for extracting seasonality information from noisy AVHRR NDVI data, but the current version is able to accept different types

of remotely sensed time-series (e.g. data from MODIS Terra/Aqua). The advantages of TIMESAT are (i) it is freely available open source software, (ii) it provides three different smoothing functions to fit time series data, (iii) a user-defined weighting scheme is applicable in the smoothing process, and (iv) a comprehensive set of phenology metrics is generated from the smoothed time series satellite data. The creators of TIMESAT found the program to be generally successful except when the noise level was high and growing season short. A disadvantage is that TIMESAT requires the estimation of up to 8 parameters (de Beurs and Henebry, 2010).

### 3.3 NOISE

Forest canopy NDVI derived from satellite data can be affected by factors not related to the vegetation. The constituents of a cloudless atmosphere, such as Rayleigh scattering, oxygen, ozone, water vapour and aerosols, may affect the signal by scattering or absorption (Holben, 1986; Goward et al., 1991). Also, depending on the illumination and observed geometry, the spectral bidirectional reflectance of forests may decrease or increase without any change in the forest characteristics due to bidirectional reflectance distribution function (BRDF) effects (Gutman, 1991; Deering et al., 1999). This scattering may cause the NDVI to be lower than the canopy.

The noise is partially accounted for in the MODIS algorithm (Huete et al., 1999) and much of it can be removed by eliminating the values for which the quality assessment indicate poor pixel quality. But TIMESAT is not able to calculate the temporal curve with excessive missing or poor quality data. For a time-series with one growing season per year the threshold of the retrievable data gap within TIMESAT is four months. With a larger data gap green-up information could be missing from the series and the fitted curve would not be accurate.

### 3.4 SMOOTHING

The short-frequency variation caused by noise in time-series data can be suppressed by means of running averages, running medians or compound smoothers (Van Dijk et al., 1987). There are three smoothing functions available in TIMESAT software: adaptive Savitzky-Golay filtering, asymmetric Gaussian and double logistic. The adaptive Savitzky-Golay method captures rapid changes in the time-series but it is sensitive to noise due to its use of local polynomial functions. Both asymmetric Gaussian and double logistic use semi-local methods and are less sensitive to noise. These tend to provide a better description of the beginning and end of the growing season (Tan et al., 2008). Gao et. al. (2008) found that both asymmetric Gaussian and logistic algorithms in TIMESAT produce similar results, but asymmetric Gaussian is better able to handle incomplete

time-series data. Because the hive sites are in areas where winters frequently caused landscape to be covered in snow, and the metric of concern is the SOS, the asymmetric Gaussian method was selected.

### 3.5 ASYMMETRIC GAUSSIAN METHOD

The adopted local model functions have the general form:

$$f(t) = f(t; c_1, c_2, a_1, \ldots, a_5) = c_1 + c_2 g(t; a_1, \ldots, a_5) \qquad \textit{Equation 1}$$

where

$$g(t; a_1, \ldots, a_5) = \begin{cases} \exp\left[-\left(\frac{t-a_1}{a_2}\right)^{(a_3)}\right], \textit{if } t > a_1 \\ \exp\left[-\left(\frac{a_1-t}{a_4}\right)^{(a_5)}\right], \textit{if } t < a_1 \end{cases} \qquad \textit{Equation 2}$$

is a Gaussian-type function. In equation 1, parameters $c_1$ and $c_2$ determine the base level and the amplitude. In equation 2, the parameter $a_1$ determines the time of the maximum NDVI (measured in time units). The upper part of equation 2 is fitted to the right half of the time series (time after the peak $a_1$ is reached) while the lower part of the equation fits to the left. The parameters $a_2$ and $a_4$ determine the width of the curves on the right and left side, respectively. The parameters $a_3$ and $a_5$ determine the flatness (or kurtosis) of the curves on the right and left side, respectively. The effects of varying the parameters $a_2$... $a_5$ are shown in figure 4.

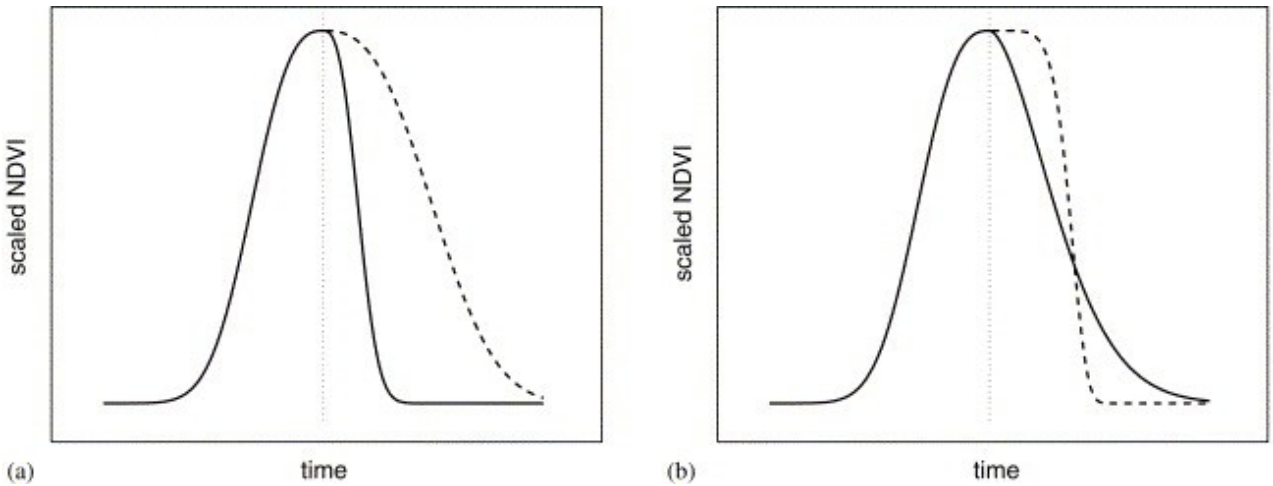



*Figure 4: Effect of parameter changes on local functions. In (a) parameter $a_2$, which determines width of right function half, has been decreased (solid line) and increased (dashed line) compared to value of left half. In (b) parameter $a_3$, which determines flatness of right function half, has been decreased (solid line) and increased (dashed line) compared to value of left half. From Jönsson and Eklundh (2004)*

The local model functions are well suited for describing the shape of NDVI time-series in overlapping intervals around maxima and minima. If a set of data points is selected ($t_i$, $I_i$), I = $n_1$...., $n_2$ in an interval around a maximum or minimum, the parameters $c_1$, $c_2$ and $a_1$, …, $a_5$ are obtained by minimizing the merit function:

$$x^2 = \sum_{i=n_1}^{n_2} \left[ \frac{f(t_i; c_1, c_2, a_1, \ldots, a_5) - I_i}{\sigma_i} \right]^2 \qquad \textit{Equation 3}$$

where $\sigma_i$ is the measurement uncertainty of the *i*th data point, presumed to be known. If the measurement uncertainties are not known, they may all be set to the constant value $\sigma = 1$.

### 3.6 ADOPTION TO UPPER ENVELOPE

Most noise in NDVI data, even for data classified as clear by the cloud mask, is considered to be negatively biased. The determination of the parameters of the model function is done in two steps: the first parameters are obtained by minimizing the merit function with $\sigma_i$ as obtained from ancillary data. Data points below the model function of the first fit are thought of as being less important, and in the second step the minimization is redone with the $\sigma_i$ of the low data points increased by a factor of two. This two step procedure leads to a model function that is adopted to the upper envelope of the NDVI data.

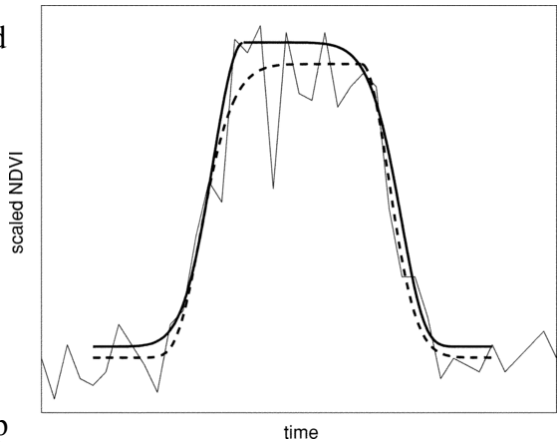



*Figure 5: Fitted functions around a maximum from the two-step procedure. The dashed line shows the fitted function from the first step, and the solid line the fit from the second step. The original NDVI time-series is shown by the noisy fine continuous line. From* Jönsson and Eklundh (2004)

### 3.7 INTEGRATION OF TEMPERATURE DATA

During the winter months, snow frequently covers the landscape of northern latitudes and high altitudes, preventing NDVI measurements. But because the biochemical processes of vegetation are sensitive to colder temperatures (Levitt, 1980), during times of dormancy reflective characteristics should remain constant. The photosynthesis of vegetation will increase after the temperature reaches a certain minimum threshold. Following the methodology of Tan et. al. (2008), a winter season was defined as a period longer than half a month when an area is snow-covered or the night land surface temperature is equal to or below 0º C. Using the MODIS Terra product 1km

Land Surface Temperature/Emissivity (MOD11A2: (Wan et al., 2002)) and the snow flag in the MOD13Q1 QA data, a winter season was marked for each hive location. During this time a minimum NDVI was assigned. This minimum NDVI was approximated by a clear capture at the end of the previous season's "brown down" or during a snow-free clear capture during the winter season when the night land surface temperature (LST) was below 0º C. Thus, it was possible to replace the winter season with a smooth, gap-filled curve (Figure 6).

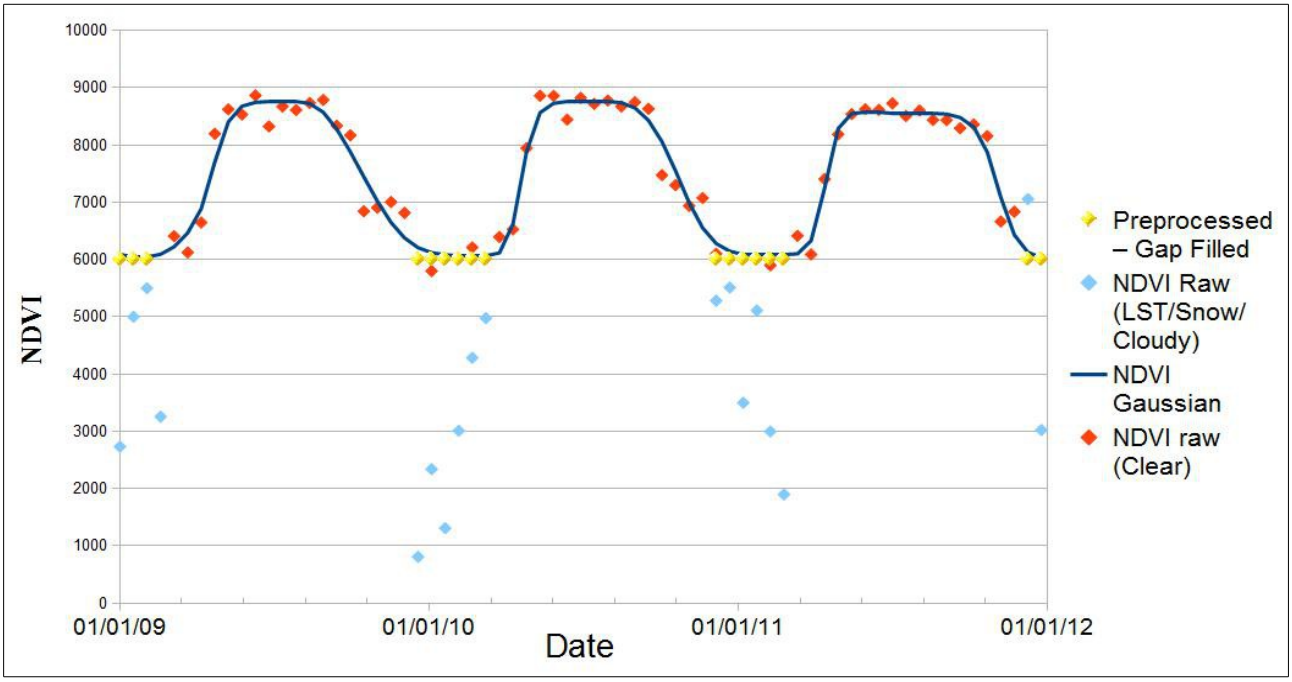



*Figure 6: An example of preprocessing NDVI data. During winter months, snow/cloud covered pixels are assigned a base NDVI value (yellow). Blue line is Gaussian curve derived by TIMESAT*

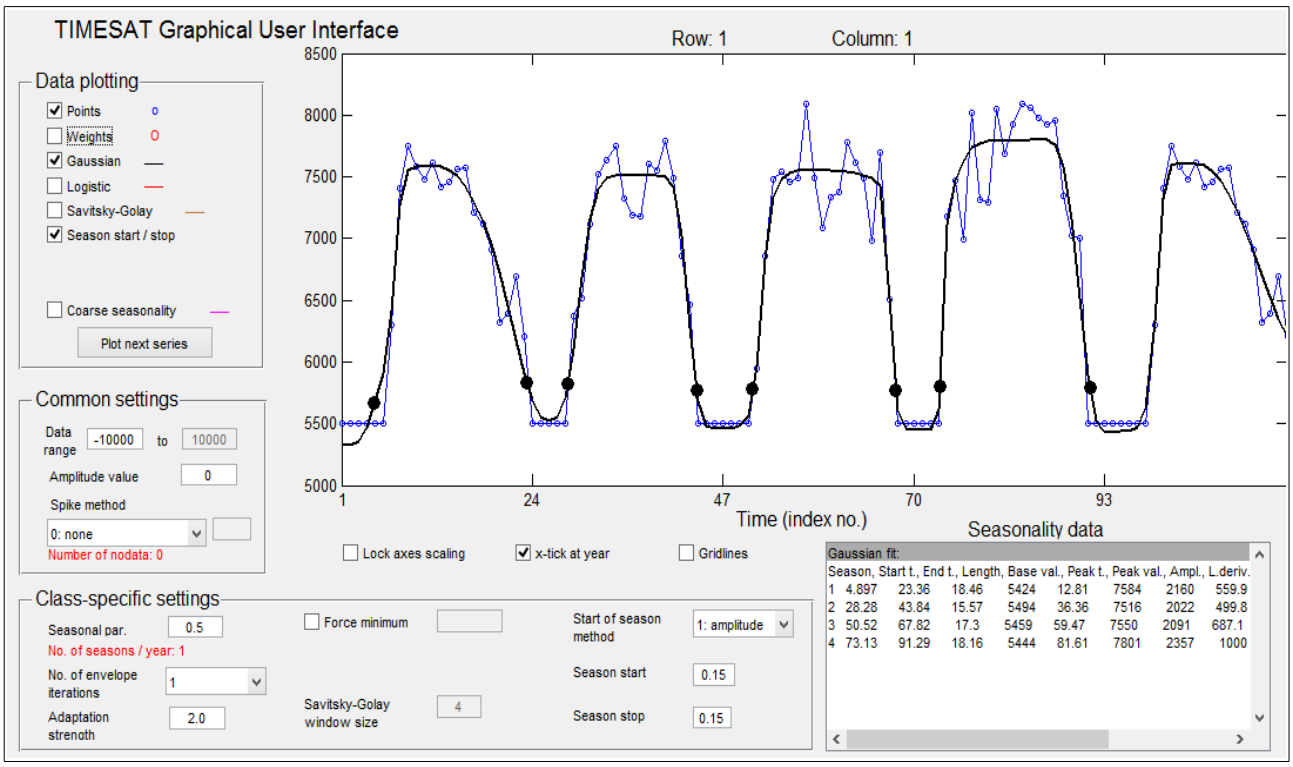



*Figure 7: The graphical interface of TIMESAT showing the parameters and settings used*

# 4. ALTERNATIVE START OF SEASON MEASUREMENT

## 4.1 INTRODUCTION

With a modest correlation found between satellite-derived SOS and HBNF, it is tempting to extrapolate these findings across the continent using a similar VI MODIS dataset. The Land Cover Dynamics Product (MCD12Q2:(Zhang et al., 2006)), consists of preprocessed yearly phenophase changes based on the Enhanced Vegetation Index (EVI). In previous research, Nightingale et al. (2008) found that EVI did not have as strong a relationship to any HBNF metrics. However, if a relationship could be found between MCD12Q2's "Onset of Greeness Increase" scientific data set (SDS) layer and the metrics of the HBNF, it would be simple to map the HBNF of Europe during the time period 2001-2010.

Staring with the launch of Terra and Aqua satellites in 2000, EVI has been adopted as a standard product by NASA and enthusiastically accepted in the research community (e.g. Huete et al., 2002). Like NDVI, it is produced at varying spatial (250m, 1km, 0.05 degree) and temporal (16-day, monthly) resolutions across the entire globe. Where the NDVI is chlorophyll sensitive, the EVI is more responsive to canopy structural variations, including leaf area index (LAI), canopy type, plant physiognomy and canopy architecture (Gao et al., 2000). EVI has improved sensitivity over high biomass regions and improved vegetation monitoring capability through a de-coupling of the canopy background signal. It minimizes canopy background variations to maintain sensitivity over dense vegetation and uses the blue band to remove residual atmosphere contamination caused by smoke and sub-pixel thin clouds (Huete et al., 1999). EVI is calculated:

$$EVI = G\frac{\rho NIR - \rho red}{\rho NIR + C_1 * \rho red - C_2 x\ \rho blue + L} \qquad \textit{Equation } 4$$

where ρ are atmospherically corrected or partially atmospherically corrected (Rayleigh and ozone absorption) surface reflectances, L is the canopy background adjustment that addresses non-linear, differential NIR and red radiant transfer through the canopy, and $C_1$ and $C_2$ are the coefficients of the aerosol resistance terms which use the blue band to correct for aerosol influences in the red band (Huete et al., 2002). The coefficients adopted in the EVI algorithm are L=1, $C_1$= 6, $C_2$=7.5, and G (gain factor) = 2.5 (Huete et al., 1994, 1997).

MCD12Q2 was designed to provide information related to phenology in support of ecological and global change science (Friedl, 2012). It was calculated at 500 m spatial resolution

yearly for the entire globe using the MODIS Land Cover Dynamics algorithm (MLCD) to identify phenophase transition dates based on logistic functions fit to time series of EVI. For each pixel a times series of EVI is assembled, the data undergo a gap-filling and smoothing process, periods of sustained EVI increase or decrease are identified, logistic models are fit to the time series and transition dates are identified as local maxima and minima in the rate of change of curvature of the fitted logistic function (Zhang et al., 2003, 2006; Ganguly et al., 2010). Four dates are calculated for two full vegetation cycles of each pixel. These dates correspond to the onset of EVI increase (green up), the onset of EVI maximum (maturity), the onset of EVI decrease (senescence) and the onset of EVI minimum (dormancy).

MLCD product uses EVI calculated from composited 8-day normalized BRDF-adjusted reflectance data (MCD43A4: (Schaaf et al., 2002)) with two full years of Nadir BRDF-Adjusted Reflectance (NBAR)-EVI observations assembled using a window that includes six months of data before and after the 12-month period of interest. MCD43A4 data are produced every 8-days using overlapping 16-day compositing windows, creating a possibility of 46 EVI values for a year and as many as 92 EVI observations for the entire MLCD time series. However in practice the number of observations available in any MLCD two-year window is much less due to cloud cover, aerosols and snow/ice cover. The MLCD algorithm removes snow and ice with a flag from the MCD43A2 BRDF-Albedo Quality product and replaces it with the most recent snow/ice free value. The collection 5 MODIS LST product (MOD11A2: (Wan et al., 2002)) is used to further filter the EVI time-series by replacing those observations where LST is lower than 5º C with background, snow-free values. This step accounts for cases where the NBAR product fails to accurately identify snow or ice and where vegetation is otherwise assumed to be biologically inactive. Remaining gaps in the time series are removed using a three-date moving window average, and the series are smoothed using a three-point median-value moving-window technique as described in Zhang et. al. (2006).

Sustained periods of EVI increase are determined from the filtered, gap-filled and smoothed EVI time series using moving windows composed of 5 consecutive observations. Transient variations in EVI, which may cause spurious detection of transitions, are excluded by requiring that the local maximum EVI value be at least 70% of the annual maximum and that the change in EVI must exceed 35% of the annual amplitude. For each identified period of sustained EVI increase or decrease, sigmoid curves are fit to the corresponding EVI time series using non-linear least squares. Phenophase transition dates are then estimated by identifying local maxima and minima in the rate of change in curvature of the fitted logistic function (Zhang et al., 2003).

MCD12Q2 has some known issues that may hinder it's use. It is designed for the northern

hemisphere, is less accurate at high latitudes during the winter and does not detect subtle change (e.g., some areas with evergreen vegetation). The algorithm has more difficulty in the tropics where vegetation follows a more complex cycle pattern. The product allows a pixel to display two phenological cycles, but because vegetation phenology does not follow a uniform annual cycle everywhere, pixels can contain incomplete cycles in any 12 month period and incomplete cycles are not marked. Also, a major problem for MCD12Q2 is that that the quality control SDS in Collection 5 of this product was discovered to be corrupted due to a bug in the source code and it has not been produced since 2010.

## 4.2 DATA AND METHODS

### 4.2.1 MODIS

MODIS Land Cover product (MCD12Q2) was acquired from NASA's Earth Observing System Data and Information System's Reverb ECHO website (http://reverb.echo.nasa.gov/reverb/). Data was acquired from 2009 and 2010 for the extent of Europe. Each dataset came compressed as Hierarchical Data Format (HDF) containing 7 SDS. The first SDS (Onset_Greenness_Increase) contained two bands, each representing a separate phenological cycle. Only the first cycle was selected and mosaicked using QGIS. From each mosaic, raster calculator was used to replace fill (=32767) with null values and the ordinal day was calculated from its given format (# of days from January 2000). Available scale-hive data points were overlain and buffered to 3 kilometres. The zonal statistics tool was used to calculate the mean onset greenness increase within 3 kilometres of each hive.

### 4.2.2 HBNF

HBNF metrics and TIMESAT NDVI SOS were calculated as described in Blomstedt (2014). Due to the available time frame of MCD12Q2, only hive locations with data from 2009 and 2010 were used in this analysis.

## 4.3 RESULTS AND DISCUSSION

*Table 3: Onset EVI Greenness by year and location*

| Location | Year | TIMESAT NDVI SOS | Onset EVI Greenness (3km Mean) | Onset EVI Greenness (centre pixel) | HBNF 50% |
|---|---|---|---|---|---|
| | | Ordinal Day | | | |
| Vaz | 2009 | 110 | 117 | 118 | 142 |
| Grangeneuve | 2009 | 64 | 79 | 75 | 130 |
| Grangeneuve | 2010 | 68 | 129 | 79 | 118 |
| Ath | 2010 | 70 | 73 | 69 | 134 |
| Aubel | 2010 | 64 | 89 | 71 | 118 |
| Arlon | 2010 | 99 | 84 | 91 | 144 |
| Dekani | 2010 | 89 | 83 | 89 | 141 |

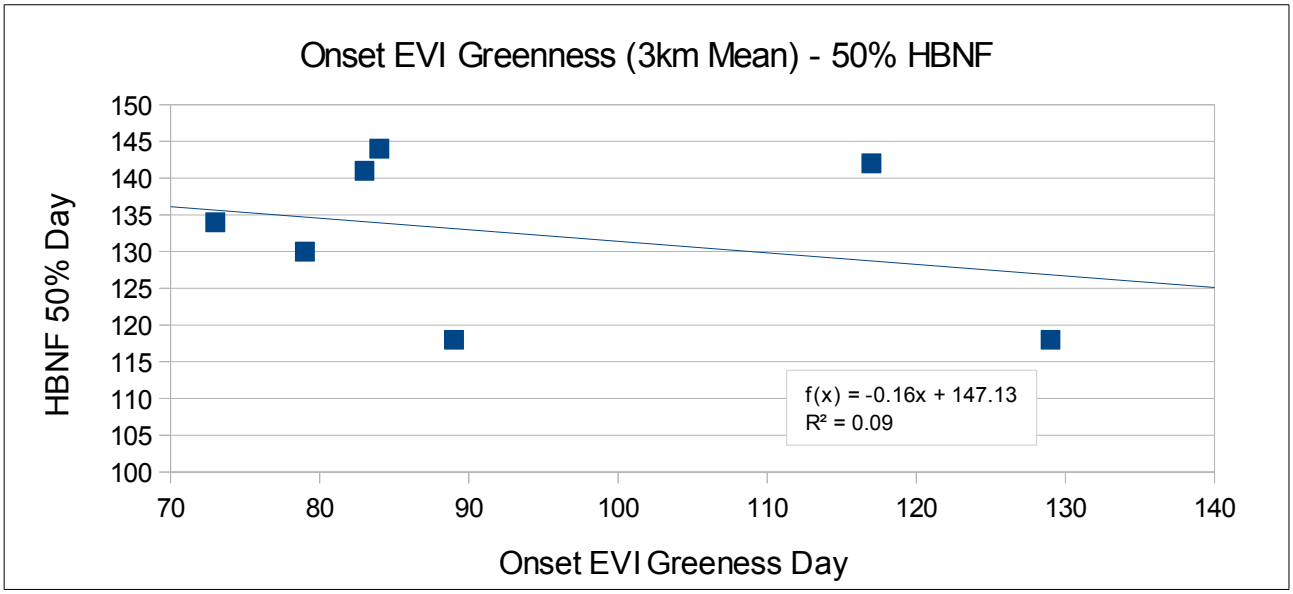



*Figure 8: Onset EVI Greenness (3km Mean), n=7*

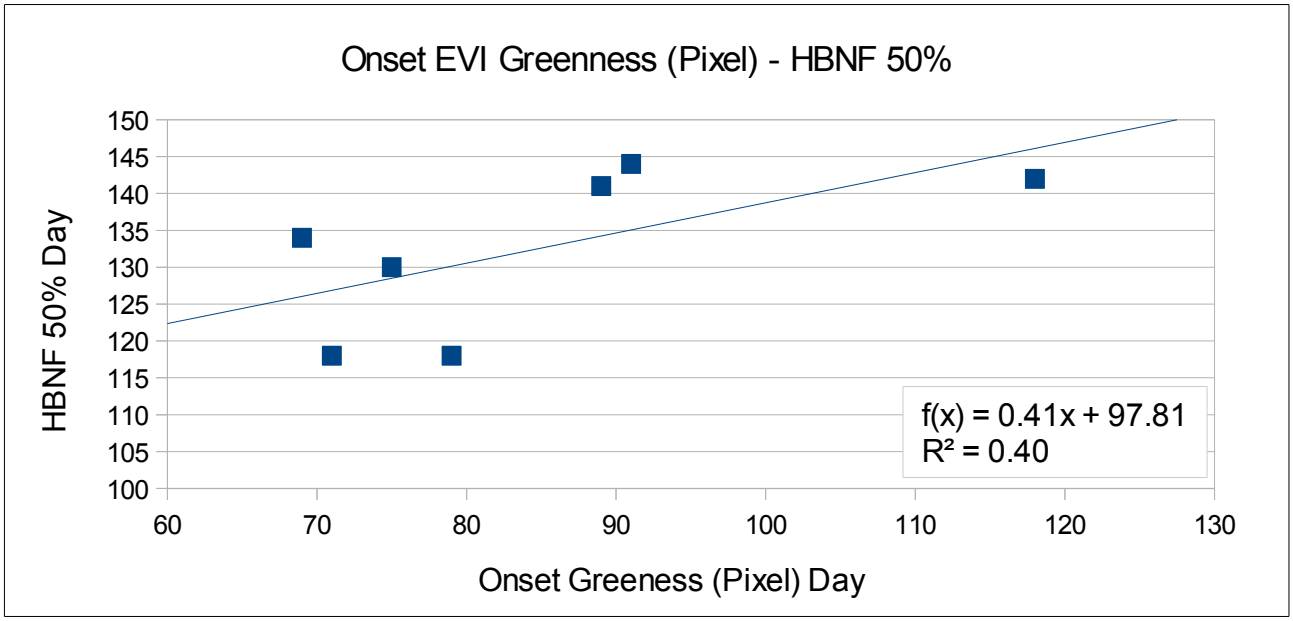



*Figure 9: Onset EVI Greenness (Pixel), n=7*

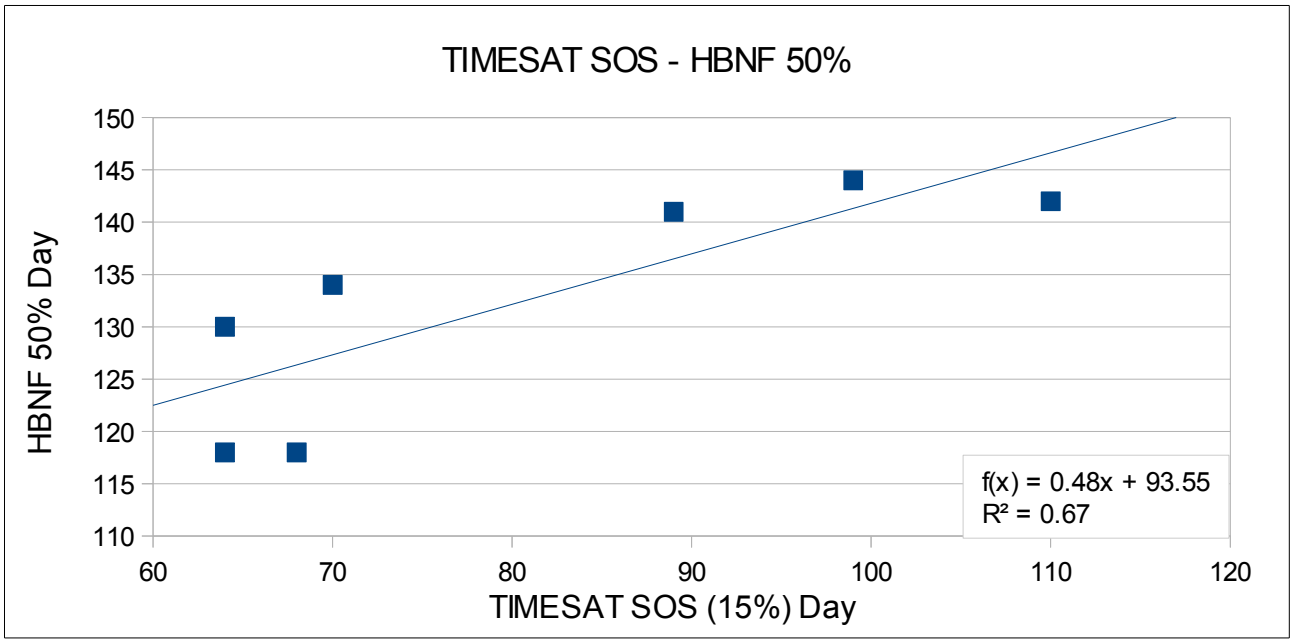



*Figure 10: TIMESAT SOS – HBNF 50%, n=7*

Comparison of the EVI onset of greenness 3km mean and HBNF 50% shows no relationship (Figure 8, $R^2$= 0.09). This is likely due to the high variation in onset date within a 3 kilometre radius of each hive. For example, the 2010 Grangeneuve hive is within a pixel that has an onset date of 79, but is surrounded by pixels with dates 145, 146, Null, 204, 127, 127, 155 and 84. It is difficult to believe that a location less than a kilometre away would have an SOS 125 days (4 months) difference. Also, these values differ greatly from the surrounding pixels in 2009, and it is uncertain if the bug discovered in QA control is the reason for this. These high numbers lead to an elevated mean and a weak relationship.

In an attempt to remove these higher values, the centre 500 x 500 metre pixel in which the hive was located was used as the SOS day. This analysis brought a stronger relationship (Figure 9, $R^2$ = 0.40) but it still is not as strong as TIMESAT NDVI of the same locations and years (Figure 10, $R^2$ =0.67). This may be due to the higher resolution of NDVI (MOD13Q1, 250 meters) used to derive SOS with TIMESAT, HBNF's weaker relationship found with EVI (Nightingale et al., 2008), the MCLD algorithm or the product's malfunctioning quality assessment.

### 4.4 CONCLUSION

These results suggest that the MCD13Q2 product does not relate well the HBNF metrics. Though it is a ready-made MODIS product for use in phenological studies, it cannot be used in mapping nectar flows.

# 5. HBNF INTERPOLATION

## 5.1 INTRODUCTION

Interpolation is the process of using point-field data to predict values in unsampled locations and generate continuous maps. Interpolation is based on the first rule of geography defined by Tobler (1970) as “Everything is related to everything else, but near things are more related than distant things.” Inverse Distance Weighting (IDW) is a local deterministic technique where a surface is created based on a model, algorithm and user defined parameters (De Smith et al., 2007). It is exact, meaning it must honour the measured point values, and uses a weighted moving average with a specified number of neighbouring points. IDW implements a distance-weight function so that at a greater distance, the cell has less influence on the output.

Like elevation, rainfall or temperature, HBNF metrics are spatially dependant and have the potential to be mapped as a spectrum across the landscape. Interpolation maps offer a way to make data more accessible. This portion of research aims to visualize the HBNF data and answer the following questions.

1. What are the spatial patterns of HBNF for each country?
    1.1. Do HBNF occur later at a higher elevation?
    1.2. Do HBNF occur earlier with proximity to the coast?

## 5.2 METHODOLOGY

HBNF metrics were used from the same locations as Blomstedt (2014). Two to four other sites per country were used as additional data to aid in interpolation. The data collection of these sites was often not as precise or regular as the original locations. The year 2011 was used due to it having a complete set of data points from every country and interpolation was performed on HBNF start day and 50% day.

## 5.3 RESULTS AND DISCUSSION

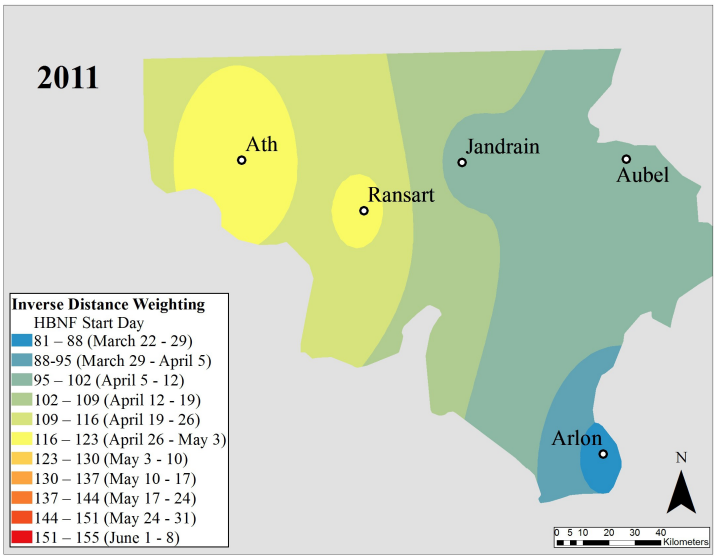



*Figure 11: Belgium HBNF Start Day 2011*

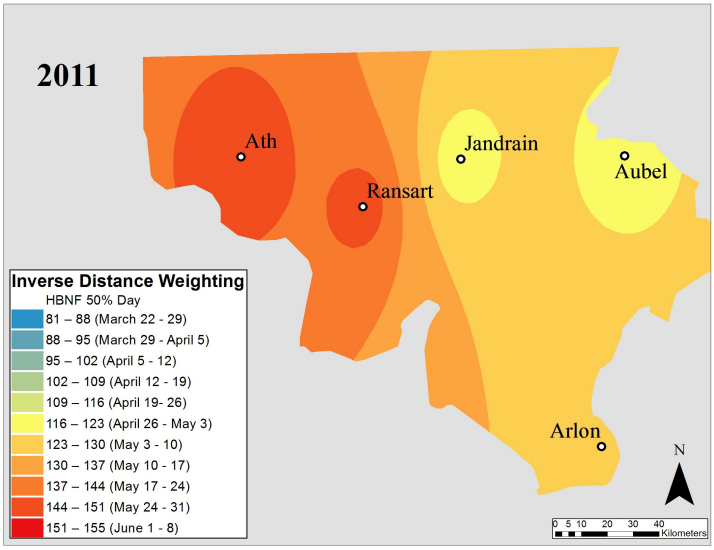



*Figure 12: Belgium HNBF 50% Day 2011*

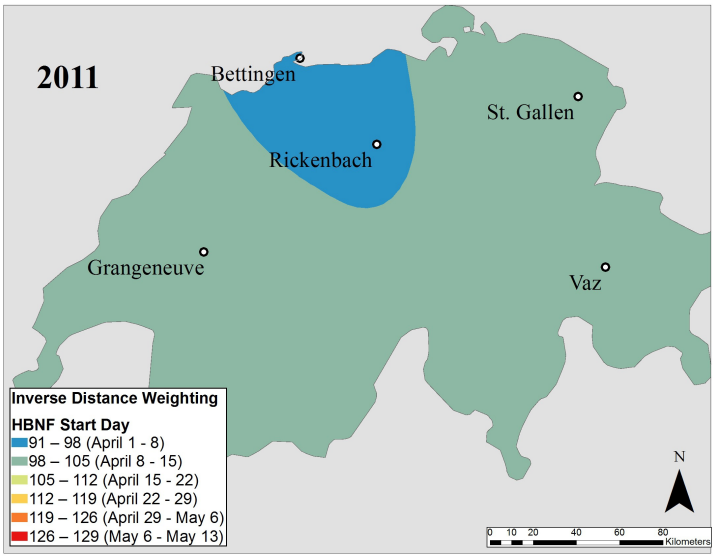



*Figure 13: Switzerland HBNF Start Day 2011*

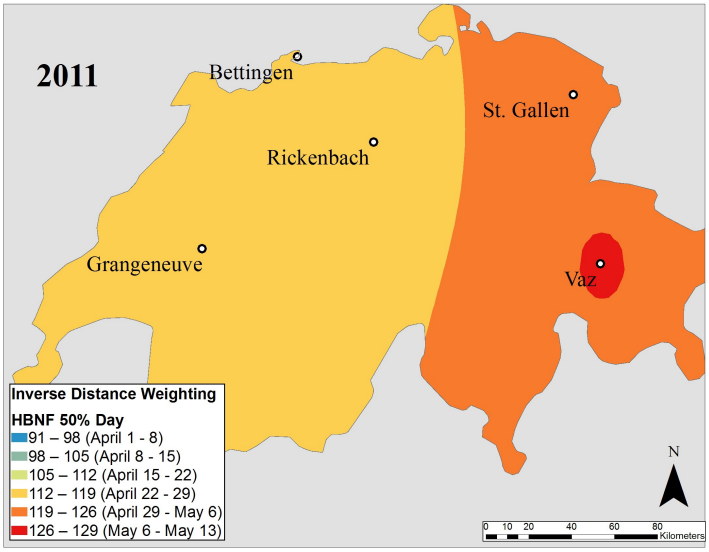



*Figure 14: Switzerland HBNF 50% Day 2011*

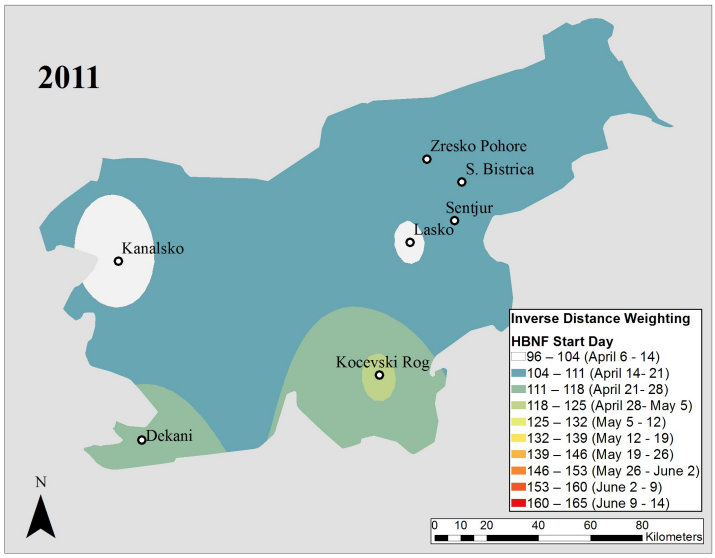



*Figure 15: Slovenia HBNF Start Day 2011*

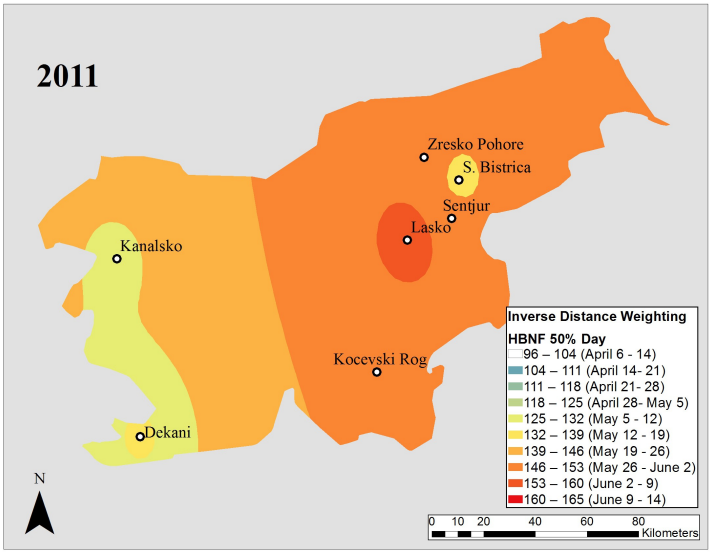



*Figure 16: Slovenia HBNF 50% Day 2011*

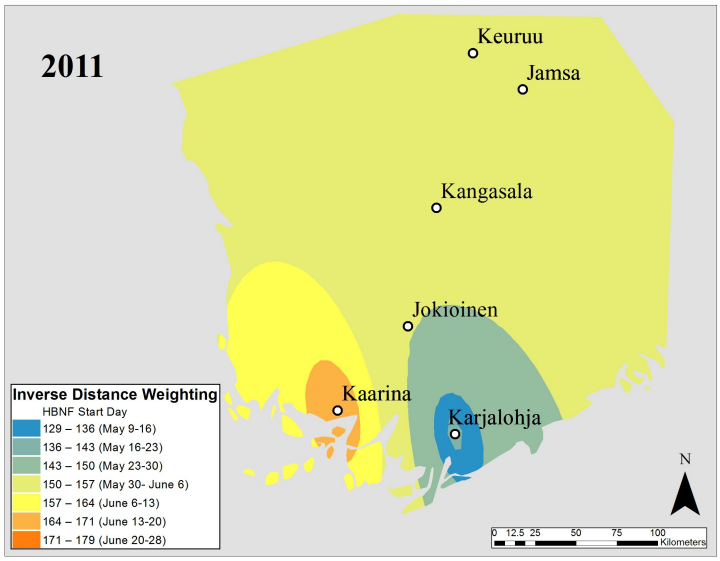



*Figure 17: Finland HBNF Start Day 2011*

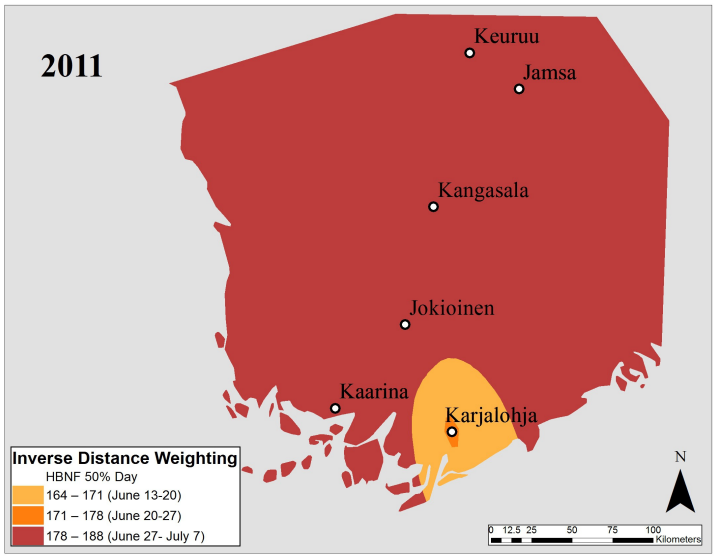



*Figure 18: Finland HBNF 50% Day 2011*

The interpolated surfaces show a rough estimate (one week) of the HBNFs by country during 2011. Belgium's HBNFs occurred earlier inland, in the eastern part of the country (Figure 11-12). In Switzerland, the flow in the lower north began a week earlier than in the higher elevations (Figure 13). The Swiss 50% day map shows Vaz, which is at an elevation of 1162 metres, had a much later flow (Figure 14). Slovenian flows occurred later in the southern part of the country, with Kočevski Rog and Laško having long flows and later 50% days (Figure 15-16). In Finland, both Karjalohja and Kaarina are located near the coast, but the former had an early NF start while the latter was later than the rest of the country by two weeks (Figure 17). However the 50% day occurred in the same week for nearly all Finnish locations (Figure 18).

Spring HBNFs are highly heterogeneous and vary greatly by location and year. A variety of environmental and geographical factors influence the HBNF. Elevation, in particular, will determine local flora species and will cause later bloom-time. This can be generally seen in the Swiss map (Figure 13), with the lower north valley having an earlier NF start than the rest of the alpine country. This appeared to even out by HBNF 50% day, and Vaz in the eastern part of the country had a longer, later flow (Figure 14). However the HBNF did not follow other assumed patterns. In Belgium the two hives closest to the coast (Ath, Ranset), which were also lower in elevation, had later HBNF start and 50% days (Figures 11-12). Finland's two coastal hives NF start differed by a month (Karjalohja = May 9, Kaarina = June 9) while the inland hives all began in the same week (Figure 17). Animations were created with ArcGIS for the 2011 Slovenia and Switzerland seasons to show the weekly progression of the HBNFs through the spring. These can be found on the

research website (http://www/geos.ed.ac.uk/~mscgis/13-14/s1356375/).

## 5.4 CONCLUSION

In actuality, maps of HBNF are likely to be much more detailed and nuanced. Nectar secretion is often related to temperature (Jakobsen and Kritjánsson, 1994) and microclimates created by natural formations or urban settings will influence the local HBNF. Phenology is shown to be more advanced in urban settings (Roetzer et al., 2000), and hive locations Ath, Arlon and St. Gallen are within urban influence. The four adjacent hives in eastern Slovenia (Figure 15) illustrate a pattern that is more likely than the broad, interpolated sweep across dozens of kilometres (e.g. Switzerland, figures 12-13). However this exercise gives an interesting baseline for interpolating scale-hive point data into a continuous surface. To the author's knowledge, no research of this kind has been published. With additional scale-hive data points, continuous years of data, as well as geostatistical techniques which incorporate elevation, honey flows could be more precisely quantified and mapped at a landscape level.

## 6. LIMITATIONS OF STUDY

### 6.1 MODIS

Investigations of seasonal changes and interannual variability of global vegetation activity using satellite-derived NDVI must assume that changes in NDVI are based on vegetation response to climate. Interannual signal is subtle and subject to non-vegetated effects. Satellite drift, calibration uncertainties, inter-satellite sensor differences, bidirectional and atmospheric effects, can introduce variability and be misidentified as NDVI changes.

What is actually measured in remote sensing SOS is poorly understood and likely varies depending on the land cover. For example, the initial greening LSP may be the measurement of the understory rather than the canopy. This may lead to some error, but as seen in figure 15 of Blomstedt (2014), it is not likely the NDVI, but the duration of the HBNF which is shifting the points away from the linear trend.

MODIS data used in this project (MOD13Q1) is produced at 16 day intervals and may be too temporally coarse for studying a phenological metric which may only be changing at a fraction of day per year. The MOD13Q1 algorithm reviews the captures from the 16 day period and selects maximum value across all observations for that pixel. This value is assigned to the date of production, though it may come from a capture over two weeks prior. For the next date of production, 16 days later, the clearest NDVI value may fall at the end of that interval, making the actual capture dates four weeks apart. This study attempts to remedy this potential error by averaging the pixel values for one production period and applying a Gaussian smoothing to the time-series.

### 6.2 SCALE WEIGHT DATA

One source of uncertainty arrives from methods and equipment used to collect scale-hive data. Not only does each country in Europe have their separate scale-hive network, with their own type of scale and beehive, but each scale-hive is tended by an individual beekeeper. The practices of a beekeeper has a strong influence on the hive's productivity and health. For example, removing honey combs from a hive causes stress in the colony, causing a smaller harvest (Szabo and Lefkovitch, 1991). Szabo and Mueller (1996) describe colony management practices that promote accurate measurement of weight, but it is not known what beekeeping methods were used for the scale-hives in this research. The scale-hive network in the US has an extensive protocol on how to make scale-hive measurements that provide insight across the regions (Esaias, 2007). The important points include

- **Exposure to the elements** – If a hive is not sheltered the scale may register weight gain from precipitation. It's possible for a rainfall-induced weight gain last up to 36 hours (Meikle et al., 2006).
- **Storage space** – If the colony runs out of empty comb they will not be able to store additional nectar and they will cease foraging even if there is still a flow. A lack of space also encourages swarming.
- **Swarming** – If the hive is not carefully and frequently inspected in the spring, the bees may swarm causing both a change in weight as well as a weakened colony for the remainder of the spring.
- **Size, strength and health of colony** – These three traits depend on the environment, genetics of the bees and management the beekeeper. While colonies should gather nectar relative to their size and strength, all colonies cannot be considered the same. If a colony is weakened from illness, pests or pesticides, it may not be able to forage properly. There are as many ways to remedy the above maladies as there are beekeepers.
- **Recording of weight changes** – feeding a colony syrup, pollen patties, adding supers, empty comb, harvesting honey all effect the weight of a hive. A fastidious beekeeper will note each change and adjust the weight, but at times these notes are forgotten. Of concern are the Swiss hives used in this study, which stated the data-user must make these judgements from looking at the numbers.

Also, of note, scale weight does not truly distinguish between collection of nectar, pollen, water or propolis, production of brood or wax, and bees themselves (McLellan, 1977). The number of bees may triple or quadruple during the spring season, accounting for a few kilograms. Stored honey always represents more than half the colony weight, pollen does not comprise more than 10% and wax less than 1%. However, changes in hive weight do correlate closely (r=0.95 on average) with honey production (McLellan, 1977).

### 6.3 WEATHER

Weather and other environmental factors influence bees ability to forage for pollen and nectar. During a rainy spring, bees may not be able leave their hive to forage for food. Heavy or prolonged rains also may cause damage to blossoms, causing the nectar flow to slow or cease. Data on rainfall was not offered for most of the scale-hive locations and was not taken in account for this research.

## 6.4 FORAGING

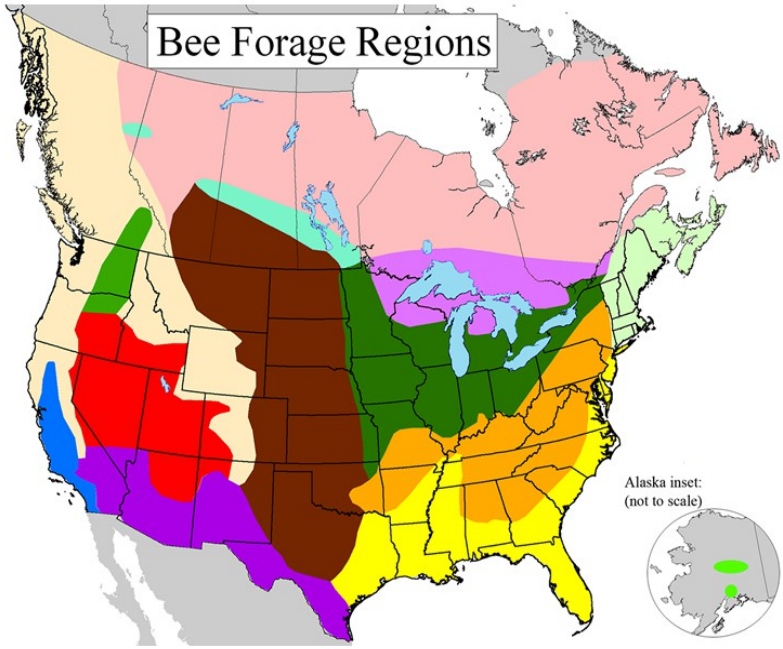
One of the important choices of a foraging bee is what to collect. This is partly determined by the availability of flowers in the field, but there is always a consistent proportion of foragers for nectar and pollen (Seeley, 1995). Workers tend to visit only one species of flower on a trip, aligning with the pollination requirements of the plant. They continue to visit that flower for prolonged periods until it cease to produce nectar or pollen or until a superior source becomes available (Winston, 1991). Hence, a colony may not give a true picture of the flowers in the landscape

It is not uncommon to find two beehives in the same location with one hive gathering fresh nectar and the other unsuccessfully scouting. This can be seen in Waddington (1994), where two matched colonies found different sources of nectar. As with any individual animal, searching ability, environment and luck are factors in foraging.

## 6.5 NECTAR SOURCES – FORAGE ZONES

The floral sources for the HBNFs used in this research were not identified. The scale-hives were spread over thousands of kilometres and 15º latitude, with the species of melliferous flowers likely differing greatly. Some scale-hive data identified forage from surrounding area (See table 1 in Blomstedt (2014)). Other scale-hive data contained notes by beekeepers who knew the floral source of the NF. However these notes were not provided with enough regularity to incorporate, and this analysis did not consider the particular nectar sources. HBNFs from agricultural sources (e.g. a field of *Brassica napus*) could have a very different effect than a HBNF from wildflowers or urban gardens. Instead this study aspired in simplicity and considered the local HBNF as a whole. Further research could look at scale-hives in a more narrow geographical range while considering NF sources.

There have been attempts to divide Europe into similar ecological regions (Mücher et al., 2003; Metzger et al., 2005; Council Directive, 1992) but there is not one specifically made for honey bee forage. For North American beekeepers, Ayers and Harman (1992) created a honey bee forage classification with 14 regions based on natural patterns of land use and flora (Figure 19). This is an avenue for further research, though at a European scale it may be more difficult due to the continent's complex geology and land-form patterns (Jay Harman, personal communication).




| | |
|---|---|
| Region 1 - Alaska | |
| Region 2 - Western Mountains | |
| Region 3 - South and Central California | |
| Region 4 - Interior Northwest | |
| Region 5 - Intermountain Region | |
| Region 6 - Southwest Deserts | |
| Region 7 - Aspen Parkland and Peace River Valley | |
| Region 8 - Great Plains | |
| Region 9 - Northern Great Lakes and Southern Canada | |
| Region 10 - Agricultural Interior | |
| Region 11 - Appalachian-Ozark Upland | |
| Region 12 - Atlantic and Gulf Coastal Plain | |
| Region 13 - New England and Atlantic Canada | |
| Region 14 - Boreal Forest | |

*Figure 15: Bee Forage Regions of North America. From Ayers and Harman (1992)*

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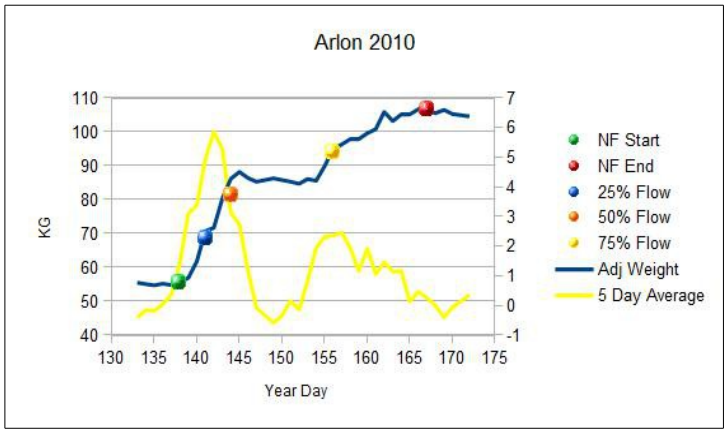
# Mapping the Phenology of European Honey Bee Nectar Flows

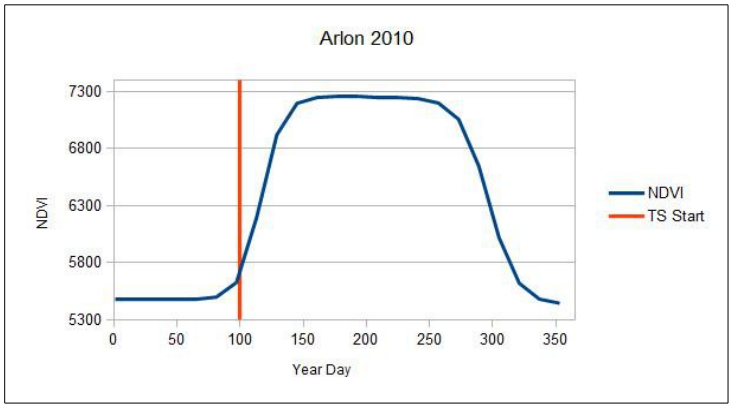
## Part II-B: Appendices

| Name | X | Y | Ele. (m) | DMEER |
|---|---|---|---|---|
| Arlon | 49.6833 | 5.7999 | 376 | Western European Broadleaf forests |

| 2010 HBNF | Day | Weight (KG) |
|---|---|---|
| NF Start | 138 | 55.7 |
| NF End | 167 | 106.6 |
| NF Duration | 29 | 50.9 |
| Quarter | | 12.725 |
| 25% Flow | 141 | 68.425 |
| 50% Flow | 144 | 81.15 |
| 75% Flow | 156 | 93.875 |



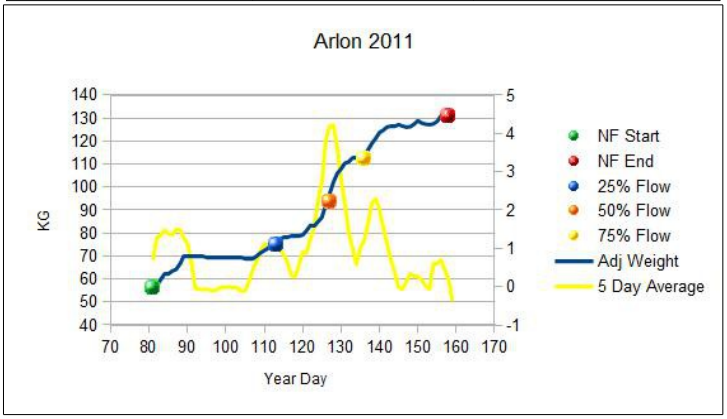

| 2010 NDVI | Day | | Value |
|---|---|---|---|
| SOS | 99.36 | Base val | 5429 |
| End | 332.32 | Peak val | 7252 |
| Length | 15.59 | Ampl. | 1794 |
| Peak t | 219.04 | L.deriv. | 662.4 |
| | | R.deriv. | 507.7 |
| | | L.integral | 101900 |
| | | S.integral | 20090 |



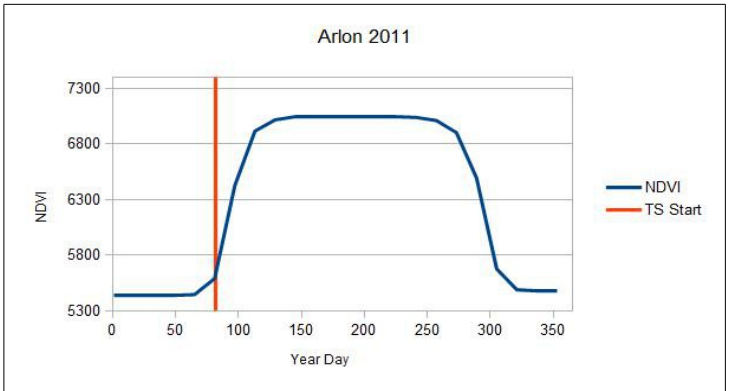

| 2010 | | | |
|---|---|---|---|
| Day | Adj KG | Adj Day | 5 Day Avg |
| 131 | 56 | -0.7 | -0.14 |
| 132 | 55.7 | -0.3 | -0.18 |
| 133 | 55.5 | -0.2 | -0.4 |
| 134 | 55.1 | -0.4 | -0.16 |
| 135 | 54.7 | -0.4 | -0.18 |
| 136 | 55.2 | 0.5 | 0.04 |
| 137 | 54.8 | -0.4 | 0.36 |
| 138 | 55.7 | 0.9 | 1.42 |
| 139 | 56.9 | 1.2 | 3.1 |
| 140 | 61.8 | 4.9 | 3.38 |
| 141 | 70.7 | 8.9 | 4.94 |
| 142 | 71.7 | 1 | 5.86 |
| 143 | 80.4 | 8.7 | 5.28 |
| 144 | 86.2 | 5.8 | 3.14 |
| 145 | 88.2 | 2 | 2.72 |
| 146 | 86.4 | -1.8 | 1.18 |
| 147 | 85.3 | -1.1 | -0.08 |
| 149 | 86.3 | 1 | -0.58 |
| 150 | 85.8 | -0.5 | -0.34 |
| 151 | 85.3 | -0.5 | 0.16 |
| 152 | 84.7 | -0.6 | -0.14 |
| 153 | 86.1 | 1.4 | 0.82 |
| 154 | 85.6 | -0.5 | 1.94 |
| 155 | 89.9 | 4.3 | 2.32 |
| 156 | 95 | 5.1 | 2.36 |
| 157 | 96.3 | 1.3 | 2.46 |
| 158 | 97.9 | 1.6 | 1.94 |
| 159 | 97.9 | 0 | 1.16 |
| 160 | 99.6 | 1.7 | 1.92 |
| 161 | 100.8 | 1.2 | 1.06 |
| 162 | 105.9 | 5.1 | 1.46 |
| 163 | 103.2 | -2.7 | 1.14 |
| 164 | 105.2 | 2 | 1.16 |
| 165 | 105.3 | 0.1 | 0.14 |
| 166 | 106.6 | 1.3 | 0.46 |
| 167 | 106.6 | 0 | 0.26 |
| 168 | 105.5 | -1.1 | 0 |
| 169 | 106.5 | 1 | -0.4 |
| 170 | 105.3 | -1.2 | -0.06 |
| 172 | 104.6 | -0.7 | 0.36 |

| Name | X | Y | Ele. (m) | DMEER |
|---|---|---|---|---|
| Arlon | 49.6833 | 5.7999 | 376 | Western European Broadleaf forests |

| 2011 HBNF | Day | Weight (KG) |
|---|---|---|
| NF Start | 81 | 56.1 |
| NF End | 158 | 130.7 |
| NF Duration | 77 | 74.6 |
| Quarter | | 18.65 |
| 25% Flow | 112 | 74.75 |
| 50% Flow | 127 | 93.4 |
| 75% Flow | 133 | 112.05 |



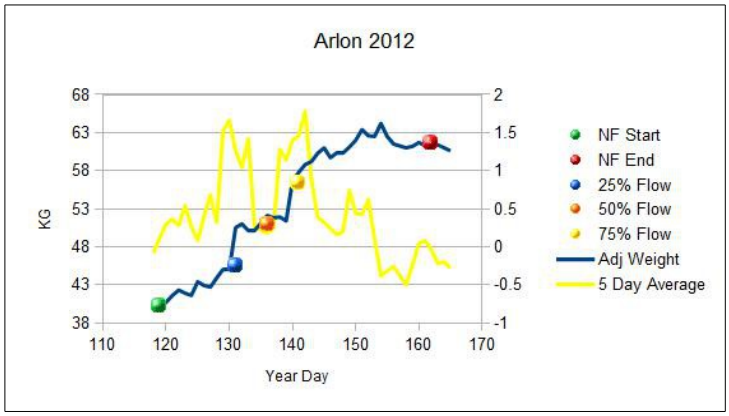

| 2011 NDVI | Day | | Value |
|---|---|---|---|
| SOS | 81.76 | Base val | 5429 |
| End | 319.2 | Peak val | 7043 |
| Length | 15.59 | Ampl. | 1584 |
| Peak t | 208.16 | L.deriv. | 685.6 |
| | | R.deriv. | 650.8 |
| | | L.integral | 101300 |
| | | S.integral | 19430 |



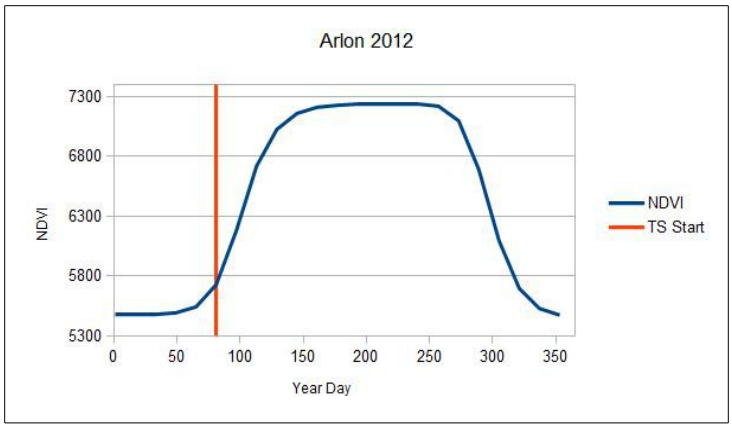

| 2011 | | | |
|---|---|---|---|
| Day | Adj KG | Adj Day | 5 Day Avg |
| 79 | 56 | -0.2 | -0.02 |
| 80 | 55.8 | -0.2 | 0.24 |
| 81 | 56.1 | 0.3 | 0.7 |
| 82 | 57.3 | 1.2 | 1.28 |
| 83 | 59.7 | 2.4 | 1.34 |
| 84 | 62.4 | 2.7 | 1.48 |
| 85 | 62.5 | 0.1 | 1.38 |
| 86 | 63.5 | 1 | 1.36 |
| 87 | 64.2 | 0.7 | 1.5 |
| 88 | 66.5 | 2.3 | 1.48 |
| 89 | 69.9 | 3.4 | 1.28 |
| 90 | 69.9 | 0 | 1.12 |
| 91 | 69.9 | 0 | 0.64 |
| 92 | 69.8 | -0.1 | -0.04 |
| 93 | 69.7 | -0.1 | -0.06 |
| 94 | 69.7 | 0 | -0.08 |
| 95 | 69.6 | -0.1 | -0.06 |
| 96 | 69.5 | -0.1 | -0.08 |
| 97 | 69.5 | 0 | -0.08 |
| 98 | 69.3 | -0.2 | -0.06 |
| 99 | 69.3 | 0 | 0 |
| 100 | 69.3 | 0 | -0.02 |
| 101 | 69.5 | 0.2 | 0 |
| 102 | 69.4 | -0.1 | -0.02 |
| 103 | 69.3 | -0.1 | -0.04 |
| 104 | 69.2 | -0.1 | -0.12 |
| 105 | 69.1 | -0.1 | -0.1 |
| 106 | 68.9 | -0.2 | 0.14 |
| 107 | 68.9 | 0 | 0.44 |
| 108 | 70 | 1.1 | 0.66 |
| 109 | 71.4 | 1.4 | 0.92 |
| 110 | 72.4 | 1 | 1.12 |
| 111 | 73.5 | 1.1 | 1.1 |
| 112 | 74.5 | 1 | 1.16 |
| 113 | 75.5 | 1 | 1.1 |
| 114 | 77.2 | 1.7 | 0.96 |
| 115 | 77.9 | 0.7 | 0.86 |
| 116 | 78.3 | 0.4 | 0.64 |
| 117 | 78.8 | 0.5 | 0.3 |
| 118 | 78.7 | -0.1 | 0.26 |
| 119 | 78.7 | 0 | 0.56 |
| 120 | 79.2 | 0.5 | 0.92 |
| 121 | 81.1 | 1.9 | 0.88 |
| 122 | 83.4 | 2.3 | 1.26 |
| 123 | 83.1 | -0.3 | 1.54 |
| 124 | 85 | 1.9 | 2.26 |
| 125 | 86.9 | 1.9 | 2.74 |
| 126 | 92.4 | 5.5 | 3.82 |
| 127 | 97.1 | 4.7 | 4.2 |
| 128 | 102.2 | 5.1 | 4.22 |
| 129 | 106 | 3.8 | 3.6 |
| 130 | 108 | 2 | 2.8 |
| 131 | 110.4 | 2.4 | 2.16 |
| 132 | 111.1 | 0.7 | 1.4 |
| 133 | 113 | 1.9 | 0.98 |
| 134 | 113 | 0 | 0.58 |
| 135 | 112.9 | -0.1 | 1.02 |
| 136 | 113.3 | 0.4 | 1.2 |
| 137 | 116.2 | 2.9 | 1.64 |
| 138 | 119 | 2.8 | 2.18 |
| 139 | 121.2 | 2.2 | 2.3 |
| 140 | 123.8 | 2.6 | 2 |
| 141 | 124.8 | 1 | 1.52 |
| 142 | 126.2 | 1.4 | 1.1 |
| 143 | 126.6 | 0.4 | 0.68 |
| 144 | 126.7 | 0.1 | 0.36 |
| 145 | 127.2 | 0.5 | -0.02 |
| 146 | 126.6 | -0.6 | -0.06 |
| 147 | 126.1 | -0.5 | 0.14 |
| 148 | 126.3 | 0.2 | 0.34 |
| 149 | 127.4 | 1.1 | 0.26 |
| 150 | 128.9 | 1.5 | 0.26 |
| 151 | 127.9 | -1 | 0.18 |
| 152 | 127.4 | -0.5 | 0.02 |
| 153 | 127.2 | -0.2 | -0.06 |
| 154 | 127.5 | 0.3 | 0.6 |
| 155 | 128.6 | 1.1 | 0.6 |
| 156 | 130.9 | 2.3 | 0.7 |
| 157 | 130.4 | -0.5 | 0.44 |
| 158 | 130.7 | 0.3 | 0.18 |
| 159 | 129.7 | -1 | -0.38 |

| Name | X | Y | Ele. (m) | DMEER |
|---|---|---|---|---|
| Arlon | 49.6833 | 5.7999 | 376 | Western European Broadleaf forests |

| 2012 HBNF | Day | Weight (KG) |
|---|---|---|
| NF Start | 119 | 40.2 |
| NF End | 162 | 61.7 |
| NF Duration | 43 | 21.5 |
| Quarter | | 5.375 |
| 25% Flow | 131 | 45.575 |
| 50% Flow | 136 | 50.95 |
| 75% Flow | 141 | 56.325 |



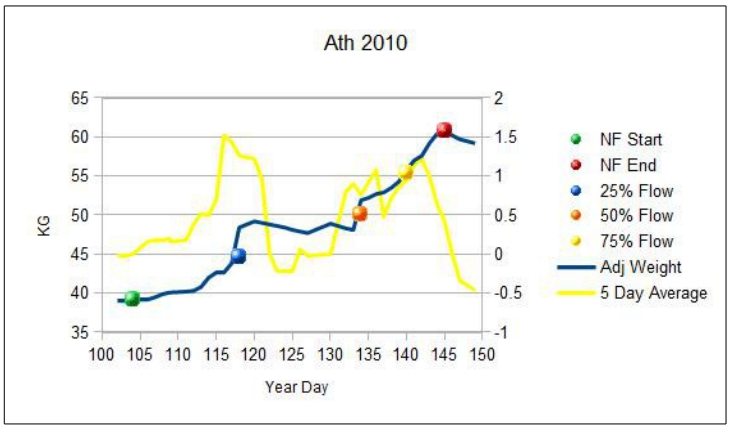

| 2012 NDVI | Day | | Value |
|---|---|---|---|
| SOS | 80.64 | Base val | 5429 |
| End | 334.88 | Peak val | 7231 |
| Length | 15.59 | Ampl. | 1763 |
| Peak t | 216.48 | L.deriv. | 455.8 |
| | | R.deriv. | 490 |
| | | L.integral | 109000 |
| | | S.integral | 21460 |



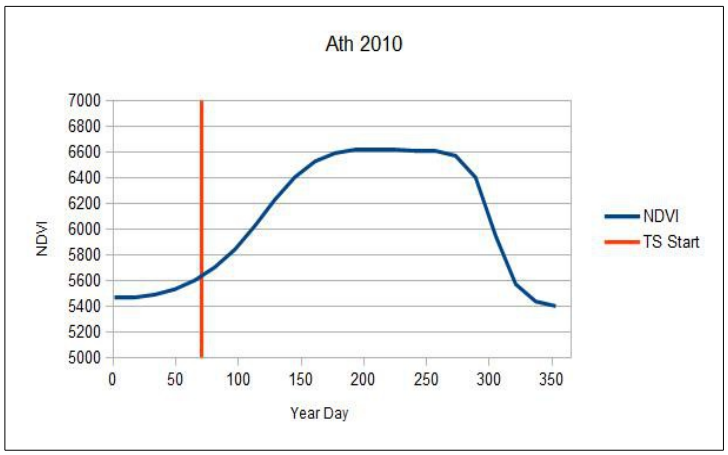

| 2012 | | | |
|---|---|---|---|
| Day | Adj KG | Adj Day | 5 Day Avg |
| 116 | 41 | -0.1 | -0.26 |
| 117 | 40.8 | -0.2 | -0.2 |
| 118 | 40.1 | -0.7 | -0.08 |
| 119 | 40.2 | 0.1 | 0.12 |
| 120 | 40.7 | 0.5 | 0.3 |
| 121 | 41.6 | 0.9 | 0.36 |
| 122 | 42.3 | 0.7 | 0.28 |
| 123 | 41.9 | -0.4 | 0.54 |
| 124 | 41.6 | -0.3 | 0.26 |
| 125 | 43.4 | 1.8 | 0.08 |
| 126 | 42.9 | -0.5 | 0.4 |
| 127 | 42.7 | -0.2 | 0.68 |
| 128 | 43.9 | 1.2 | 0.32 |
| 129 | 45 | 1.1 | 1.52 |
| 130 | 45 | 0 | 1.66 |
| 131 | 50.5 | 5.5 | 1.26 |
| 132 | 51 | 0.5 | 1.04 |
| 133 | 50.2 | -0.8 | 1.42 |
| 134 | 50.2 | 0 | 0.26 |
| 136 | 52.1 | 1.9 | 0.18 |
| 137 | 51.8 | -0.3 | 0.24 |
| 138 | 51.9 | 0.1 | 1.28 |
| 139 | 51.4 | -0.5 | 1.14 |
| 140 | 56.6 | 5.2 | 1.4 |
| 141 | 57.8 | 1.2 | 1.46 |
| 142 | 58.8 | 1 | 1.78 |
| 143 | 59.2 | 0.4 | 0.88 |
| 144 | 60.3 | 1.1 | 0.38 |
| 145 | 61 | 0.7 | 0.32 |
| 146 | 59.7 | -1.3 | 0.24 |
| 147 | 60.4 | 0.7 | 0.16 |
| 148 | 60.4 | 0 | 0.2 |
| 149 | 61.1 | 0.7 | 0.74 |
| 150 | 62 | 0.9 | 0.44 |
| 151 | 63.4 | 1.4 | 0.42 |
| 152 | 62.6 | -0.8 | 0.62 |
| 153 | 62.5 | -0.1 | 0.1 |
| 154 | 64.2 | 1.7 | -0.38 |
| 155 | 62.5 | -1.7 | -0.32 |
| 156 | 61.5 | -1 | -0.26 |
| 158 | 61 | -0.5 | -0.5 |
| 159 | 61.2 | 0.2 | -0.24 |
| 160 | 61.7 | 0.5 | 0.04 |
| 161 | 61.3 | -0.4 | 0.08 |
| 162 | 61.7 | 0.4 | -0.04 |
| 163 | 61.4 | -0.3 | -0.22 |
| 164 | 61 | -0.4 | -0.2 |
| 165 | 60.6 | -0.4 | -0.28 |

| Name | X | Y | Ele. (m) | DMEER |
|---|---|---|---|---|
| Ath | 50.6289 | 3.7614 | 38 | Southern Temperate Atlantic |

| 2010 HBNF | Day | Weight (KG) |
|---|---|---|
| NF Start | 104 | 39.2 |
| NF End | 145 | 60.8 |
| NF Duration | 41 | 21.6 |
| Quarter | | 5.4 |
| 25% Flow | 118 | 44.6 |
| 50% Flow | 134 | 50 |
| 75% Flow | 140 | 55.4 |



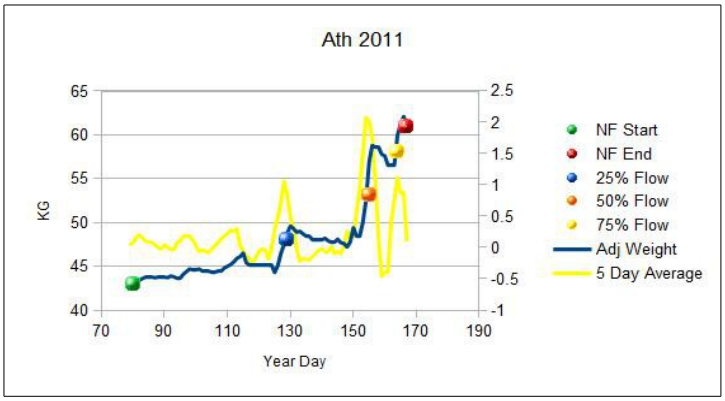

| 2010 NDVI | Day | | Value |
|---|---|---|---|
| SOS | 70.56 | Base val | 5429 |
| End | 335.84 | Peak val | 6618 |
| Length | 15.59 | Ampl. | 1189 |
| Peak t | 231.84 | L.deriv. | 175.1 |
| | | R.deriv. | 417.7 |
| | | L.integral | 106500 |
| | | S.integral | 14180 |



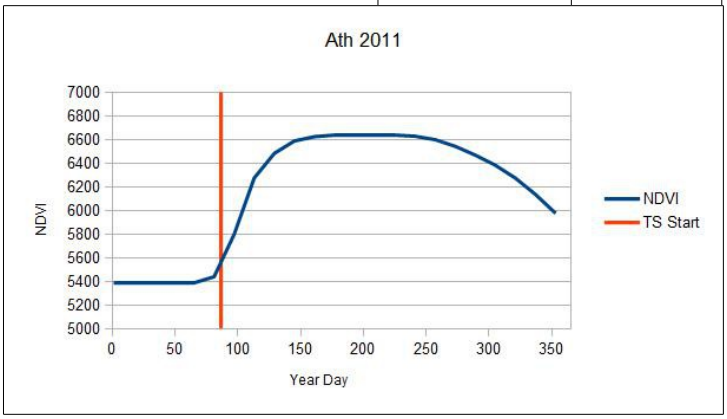

| 2010 | | | |
|---|---|---|---|
| Day | Adj KG | Adj Day | 5 Day Avg |
| 100 | 39.3 | 0 | -0.06 |
| 101 | 39.2 | -0.1 | -0.04 |
| 102 | 39.1 | -0.1 | -0.02 |
| 103 | 39.1 | 0 | -0.02 |
| 104 | 39.2 | 0.1 | 0 |
| 105 | 39.2 | 0 | 0.08 |
| 106 | 39.2 | 0 | 0.16 |
| 107 | 39.5 | 0.3 | 0.18 |
| 108 | 39.9 | 0.4 | 0.18 |
| 109 | 40.1 | 0.2 | 0.2 |
| 109 | 40.1 | 0 | 0.16 |
| 111 | 40.2 | 0.1 | 0.18 |
| 112 | 40.3 | 0.1 | 0.38 |
| 113 | 40.8 | 0.5 | 0.52 |
| 114 | 42 | 1.2 | 0.5 |
| 115 | 42.7 | 0.7 | 0.7 |
| 116 | 42.7 | 0 | 1.52 |
| 117 | 43.8 | 1.1 | 1.44 |
| 118 | 48.4 | 4.6 | 1.26 |
| 120 | 49.2 | 0.8 | 1.22 |
| 121 | 49 | -0.2 | 0.96 |
| 122 | 48.8 | -0.2 | 0 |
| 123 | 48.6 | -0.2 | -0.22 |
| 124 | 48.4 | -0.2 | -0.22 |
| 125 | 48.1 | -0.3 | -0.22 |
| 126 | 47.9 | -0.2 | 0.06 |
| 127 | 47.7 | -0.2 | -0.02 |
| 130 | 48.9 | 1.2 | 0 |
| 132 | 48.3 | -0.6 | 0.8 |
| 133 | 48.1 | -0.2 | 0.9 |
| 134 | 51.9 | 3.8 | 0.76 |
| 135 | 52.2 | 0.3 | 0.92 |
| 136 | 52.7 | 0.5 | 1.08 |
| 137 | 52.9 | 0.2 | 0.48 |
| 138 | 53.5 | 0.6 | 0.72 |
| 139 | 54.3 | 0.8 | 0.86 |
| 140 | 55.8 | 1.5 | 0.94 |
| 141 | 57 | 1.2 | 1.14 |
| 142 | 57.6 | 0.6 | 1.22 |
| 143 | 59.2 | 1.6 | 1 |
| 144 | 60.4 | 1.2 | 0.64 |
| 145 | 60.8 | 0.4 | 0.42 |
| 146 | 60.2 | -0.6 | 0 |
| 147 | 59.7 | -0.5 | -0.34 |

| Name | X | Y | Ele. (m) | DMEER |
|---|---|---|---|---|
| Ath | 50.6289 | 3.7614 | 38 | Southern Temperate Atlantic |

| **2011 HBNF** | Day | Weight (KG) |
|---|---|---|
| NF Start | 80 | 43 |
| NF End | 167 | 61 |
| NF Duration | 96 | 20.1 |
| Quarter | | 5.025 |
| 25% Flow | 129 | 48.025 |
| 50% Flow | 155 | 53.05 |
| 75% Flow | 164 | 58.075 |



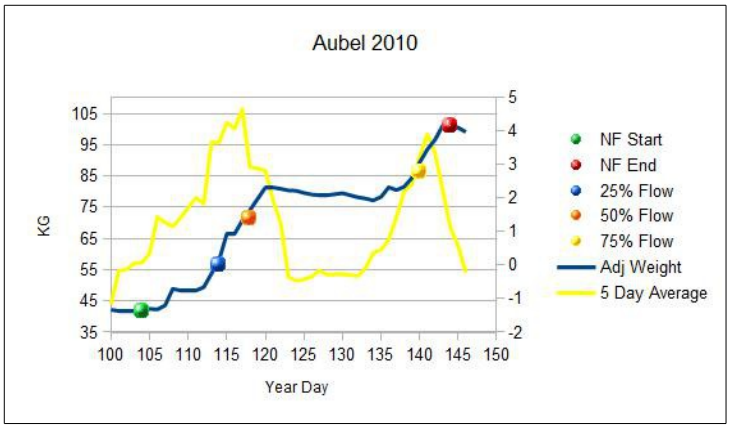

| **2011 NDVI** | Day | | Value |
|---|---|---|---|
| SOS | 86.08 | Base val | 5429 |
| End | 404.16 | Peak val | 6634 |
| Length | 15.59 | Ampl. | 1217 |
| Peak t | 226.88 | L.deriv. | 378.1 |



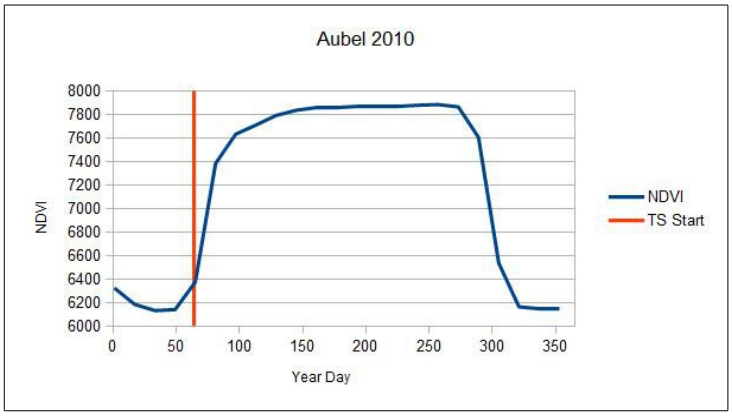

| 2011 | | | |
|---|---|---|---|
| Day | Adj KG | Adj Day | 5 Day Avg |
| 77 | 43 | 0 | -0.06 |
| 78 | 42.8 | -0.2 | -0.02 |
| 79 | 42.8 | 0 | 0.04 |
| 80 | 43 | 0.2 | 0.08 |
| 81 | 43.2 | 0.2 | 0.16 |
| 82 | 43.4 | 0.2 | 0.2 |
| 83 | 43.6 | 0.2 | 0.16 |
| 84 | 43.8 | 0.2 | 0.1 |
| 86 | 43.8 | 0 | 0.08 |
| 87 | 43.7 | -0.1 | 0.04 |
| 88 | 43.8 | 0.1 | 0 |
| 89 | 43.8 | 0 | -0.02 |
| 90 | 43.8 | 0 | 0.04 |
| 91 | 43.7 | -0.1 | 0 |
| 92 | 43.9 | 0.2 | -0.02 |
| 93 | 43.8 | -0.1 | -0.02 |
| 94 | 43.7 | -0.1 | 0.08 |
| 95 | 43.7 | 0 | 0.1 |
| 96 | 44.1 | 0.4 | 0.18 |
| 97 | 44.4 | 0.3 | 0.18 |
| 98 | 44.7 | 0.3 | 0.18 |
| 99 | 44.6 | -0.1 | 0.12 |
| 100 | 44.6 | 0 | 0.02 |
| 101 | 44.7 | 0.1 | -0.06 |
| 102 | 44.5 | -0.2 | -0.04 |
| 103 | 44.4 | -0.1 | -0.06 |
| 104 | 44.4 | 0 | -0.08 |
| 105 | 44.3 | -0.1 | -0.02 |
| 106 | 44.3 | 0 | 0.02 |
| 107 | 44.4 | 0.1 | 0.08 |
| 108 | 44.5 | 0.1 | 0.14 |
| 109 | 44.8 | 0.3 | 0.18 |
| 110 | 45 | 0.2 | 0.22 |
| 111 | 45.2 | 0.2 | 0.28 |
| 112 | 45.5 | 0.3 | 0.26 |
| 113 | 45.9 | 0.4 | 0.3 |
| 114 | 46.1 | 0.2 | 0.04 |
| 115 | 46.5 | 0.4 | -0.06 |
| 116 | 45.4 | -1.1 | -0.14 |
| 117 | 45.2 | -0.2 | -0.18 |
| 118 | 45.2 | 0 | -0.26 |
| 120 | 45.2 | 0 | -0.06 |
| 121 | 45.2 | 0 | -0.02 |
| 122 | 45.1 | -0.1 | -0.02 |
| 123 | 45.1 | 0 | -0.18 |
| 124 | 45.1 | 0 | -0.02 |
| 125 | 44.3 | -0.8 | 0.28 |
| 126 | 45.1 | 0.8 | 0.48 |
| 127 | 46.5 | 1.4 | 0.74 |
| 128 | 47.5 | 1 | 1.06 |
| 129 | 48.8 | 1.3 | 0.84 |
| 130 | 49.6 | 0.8 | 0.48 |
| 131 | 49.3 | -0.3 | 0.3 |
| 132 | 48.9 | -0.4 | -0.02 |
| 133 | 49 | 0.1 | -0.22 |
| 134 | 48.7 | -0.3 | -0.18 |
| 135 | 48.5 | -0.2 | -0.18 |
| 136 | 48.4 | -0.1 | -0.2 |
| 137 | 48 | -0.4 | -0.14 |
| 138 | 48 | 0 | -0.1 |
| 139 | 48 | 0 | -0.04 |
| 140 | 48 | 0 | -0.02 |
| 141 | 48.2 | 0.2 | -0.06 |
| 142 | 47.9 | -0.3 | -0.06 |
| 143 | 47.7 | -0.2 | 0.02 |
| 144 | 47.7 | 0 | -0.1 |
| 145 | 48.1 | 0.4 | -0.06 |
| 146 | 47.7 | -0.4 | -0.1 |
| 147 | 47.6 | -0.1 | 0.02 |
| 148 | 47.2 | -0.4 | 0.26 |
| 149 | 47.8 | 0.6 | 0.14 |
| 150 | 49.4 | 1.6 | 0.18 |
| 151 | 48.4 | -1 | 0.56 |
| 152 | 48.5 | 0.1 | 0.94 |
| 153 | 50 | 1.5 | 1.5 |
| 154 | 52.5 | 2.5 | 2.08 |
| 155 | 56.9 | 4.4 | 2.02 |
| 156 | 58.8 | 1.9 | 1.72 |
| 157 | 58.6 | -0.2 | 1.06 |
| 158 | 58.6 | 0 | 0.14 |
| 159 | 57.8 | -0.8 | -0.46 |
| 160 | 57.6 | -0.2 | -0.4 |
| 161 | 56.5 | -1.1 | -0.4 |
| 162 | 56.6 | 0.1 | 0.42 |

| Name | X | Y | Ele. (m) | DMEER |
|---|---|---|---|---|
| Aubel | 50.7048 | 5.8577 | 225 | Southern Temperate Atlantic |

| 2010 HBNF | Day | Weight (KG) |
|---|---|---|
| NF Start | 104 | 41.9 |
| NF End | 144 | 101.2 |
| NF Duration | 40 | 59.3 |
| Quarter | | 14.825 |
| 25% Flow | 114 | 56.725 |
| 50% Flow | 118 | 71.55 |
| 75% Flow | 140 | 86.375 |



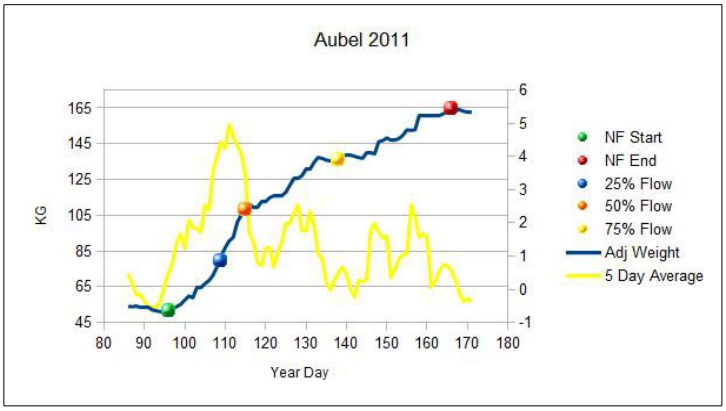

| 2010 | Day | | Value |
|---|---|---|---|
| SOS | 64.32 | Base val | 5442 |
| End | 309.6 | Peak val | 7883 |
| Length | 245.28 | Ampl. | 1744 |
| Peak t | 189.28 | L.deriv. | 701.9 |
| | | R.deriv. | 993.8 |
| | | L.integral | 128000 |
| | | S.integral | 23620 |



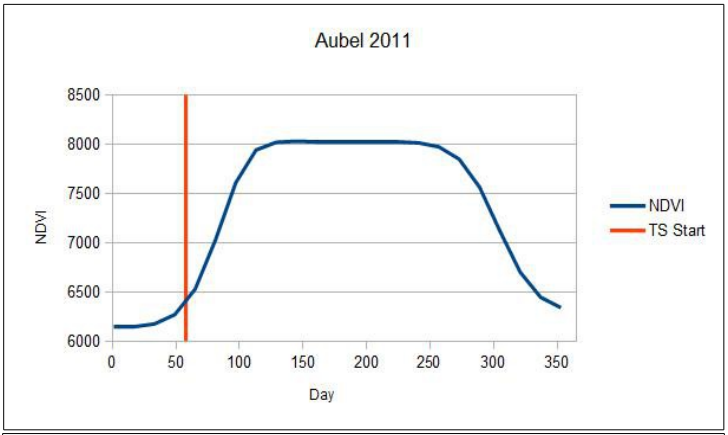

| 2010 | | | |
|---|---|---|---|
| Day | Adj KG | Adj Day | 5 Day Avg |
| 97 | 47.6 | -0.6 | -0.84 |
| 98 | 42.5 | -5.1 | -1.06 |
| 99 | 42.5 | 0 | -1.26 |
| 100 | 42.2 | -0.3 | -1.16 |
| 101 | 41.9 | -0.3 | -0.16 |
| 102 | 41.8 | -0.1 | -0.12 |
| 103 | 41.7 | -0.1 | 0.06 |
| 104 | 41.9 | 0.2 | 0.08 |
| 105 | 42.5 | 0.6 | 0.36 |
| 106 | 42.3 | -0.2 | 1.44 |
| 107 | 43.6 | 1.3 | 1.28 |
| 108 | 48.9 | 5.3 | 1.16 |
| 109 | 48.3 | -0.6 | 1.42 |
| 111 | 48.3 | 0 | 2.02 |
| 112 | 49.4 | 1.1 | 1.84 |
| 113 | 53.7 | 4.3 | 3.68 |
| 114 | 58.1 | 4.4 | 3.68 |
| 115 | 66.7 | 8.6 | 4.26 |
| 116 | 66.7 | 0 | 4.08 |
| 117 | 70.7 | 4 | 4.66 |
| 118 | 74.1 | 3.4 | 2.94 |
| 120 | 81.4 | 7.3 | 2.84 |
| 121 | 81.4 | 0 | 1.94 |
| 122 | 80.9 | -0.5 | 1.24 |
| 123 | 80.4 | -0.5 | -0.36 |
| 124 | 80.3 | -0.1 | -0.46 |
| 125 | 79.6 | -0.7 | -0.42 |
| 126 | 79.1 | -0.5 | -0.34 |
| 127 | 78.8 | -0.3 | -0.16 |
| 128 | 78.7 | -0.1 | -0.28 |
| 130 | 79.5 | 0.8 | -0.26 |
| 132 | 78.2 | -1.3 | -0.32 |
| 133 | 77.8 | -0.4 | -0.08 |
| 134 | 77.2 | -0.6 | 0.38 |
| 135 | 78.3 | 1.1 | 0.46 |
| 136 | 81.4 | 3.1 | 0.76 |
| 137 | 80.5 | -0.9 | 1.44 |
| 138 | 81.6 | 1.1 | 2.2 |
| 139 | 84.4 | 2.8 | 2.42 |
| 140 | 89.3 | 4.9 | 3.22 |
| 141 | 93.5 | 4.2 | 3.92 |
| 142 | 96.6 | 3.1 | 3.36 |
| 143 | 101.2 | 4.6 | 2.24 |
| 144 | 101.2 | 0 | 1.12 |
| 145 | 100.5 | -0.7 | 0.58 |
| 146 | 99.1 | -1.4 | -0.22 |

| Name | X | Y | Ele. (m) | DMEER |
|---|---|---|---|---|
| Aubel | 50.7048 | 5.8577 | 225 | Southern Temperate Atlantic |

| 2011 HBNF | Day | Weight (KG) |
|---|---|---|
| NF Start | 96 | 51.5 |
| NF End | 166 | 164.5 |
| NF Duration | 70 | 113 |
| Quarter | | 28.25 |
| 25% Flow | 109 | 79.75 |
| 50% Flow | 115 | 108 |
| 75% Flow | 138 | 136.25 |



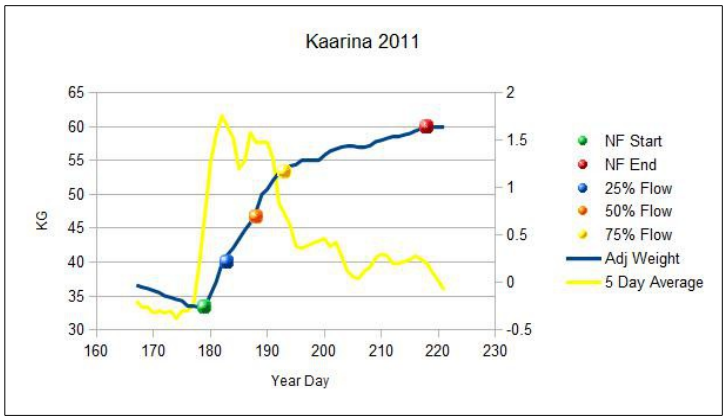

| 2011 NDVI | Day | | Value |
|---|---|---|---|
| SOS | 57.92 | Base val | 6228 |
| End | 328.32 | Peak val | 8029 |
| Length | 270.4 | Ampl. | 1801 |
| Peak t | 189.6 | L.deriv. | 525.2 |
| | | R.deriv. | 394.6 |
| | | L.integral | 143200 |
| | | S.integral | 24850 |



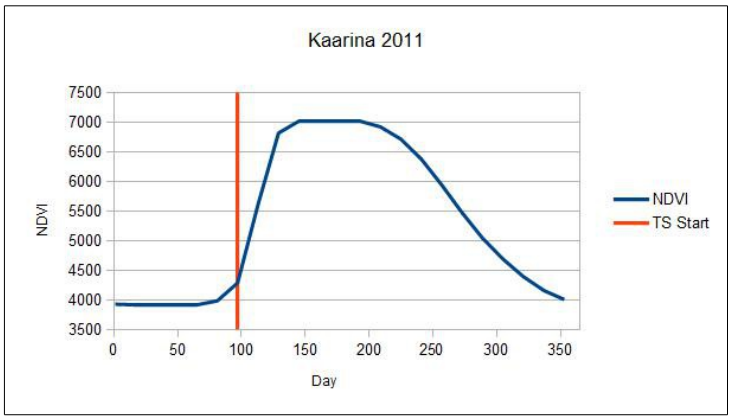

| 2011 | | | |
|---|---|---|---|
| Day | Adj KG | Adj Day | 5 Day Avg |
| 86 | 54 | -0.1 | 0.46 |
| 87 | 53.8 | -0.2 | 0.16 |
| 88 | 54.2 | 0.4 | -0.16 |
| 89 | 53.7 | -0.5 | -0.16 |
| 90 | 53.3 | -0.4 | -0.36 |
| 91 | 53.2 | -0.1 | -0.54 |
| 92 | 52 | -1.2 | -0.54 |
| 93 | 51.5 | -0.5 | -0.56 |
| 94 | 51 | -0.5 | -0.34 |
| 95 | 50.5 | -0.5 | 0.12 |
| 96 | 51.5 | 1 | 0.48 |
| 97 | 52.6 | 1.1 | 0.82 |
| 98 | 53.9 | 1.3 | 1.42 |
| 99 | 55.1 | 1.2 | 1.66 |
| 100 | 57.6 | 2.5 | 1.24 |
| 101 | 59.8 | 2.2 | 2.08 |
| 102 | 58.8 | -1 | 1.86 |
| 103 | 64.3 | 5.5 | 1.82 |
| 104 | 64.4 | 0.1 | 1.74 |
| 105 | 66.7 | 2.3 | 2.54 |
| 106 | 68.5 | 1.8 | 2.4 |
| 107 | 71.5 | 3 | 3.56 |
| 108 | 76.3 | 4.8 | 4.02 |
| 109 | 82.2 | 5.9 | 4.44 |
| 110 | 86.8 | 4.6 | 4.24 |
| 111 | 90.7 | 3.9 | 4.96 |
| 112 | 92.7 | 2 | 4.6 |
| 113 | 101.1 | 8.4 | 4.32 |
| 114 | 105.2 | 4.1 | 4.1 |
| 115 | 108.4 | 3.2 | 3.38 |
| 116 | 111.2 | 2.8 | 1.68 |
| 117 | 109.6 | -1.6 | 1.44 |
| 118 | 109.5 | -0.1 | 0.8 |
| 119 | 112.4 | 2.9 | 0.72 |
| 120 | 112.4 | 0 | 1.24 |
| 121 | 114.8 | 2.4 | 1.26 |
| 122 | 115.8 | 1 | 0.66 |
| 123 | 115.8 | 0 | 1.1 |
| 124 | 115.7 | -0.1 | 1.4 |
| 125 | 117.9 | 2.2 | 1.98 |
| 126 | 121.8 | 3.9 | 1.98 |
| 127 | 125.7 | 3.9 | 2.3 |
| 128 | 125.7 | 0 | 2.54 |
| 129 | 127.2 | 1.5 | 1.76 |
| 130 | 130.6 | 3.4 | 1.78 |
| 131 | 130.6 | 0 | 2.34 |
| 132 | 134.6 | 4 | 1.92 |
| 133 | 137.4 | 2.8 | 1.06 |
| 134 | 136.8 | -0.6 | 0.92 |
| 135 | 135.9 | -0.9 | 0.22 |
| 136 | 135.2 | -0.7 | -0.02 |
| 137 | 135.7 | 0.5 | 0.26 |
| 138 | 137.3 | 1.6 | 0.5 |
| 139 | 138.1 | 0.8 | 0.66 |
| 140 | 138.4 | 0.3 | 0.46 |
| 141 | 138.5 | 0.1 | 0 |
| 142 | 138 | -0.5 | -0.24 |
| 143 | 137.3 | -0.7 | 0.26 |
| 144 | 136.9 | -0.4 | 0.24 |
| 145 | 139.7 | 2.8 | 0.28 |
| 146 | 139.7 | 0 | 1.78 |
| 147 | 139.4 | -0.3 | 1.98 |
| 148 | 146.2 | 6.8 | 1.7 |
| 149 | 146.8 | 0.6 | 1.54 |
| 150 | 148.2 | 1.4 | 1.6 |
| 151 | 147.4 | -0.8 | 0.34 |
| 152 | 147.4 | 0 | 0.6 |
| 153 | 147.9 | 0.5 | 0.92 |
| 154 | 149.8 | 1.9 | 1.02 |
| 155 | 152.8 | 3 | 1.08 |
| 156 | 152.5 | -0.3 | 2.54 |
| 157 | 152.8 | 0.3 | 2.16 |
| 158 | 160.6 | 7.8 | 1.56 |
| 159 | 160.6 | 0 | 1.68 |
| 160 | 160.6 | 0 | 1.54 |
| 161 | 160.9 | 0.3 | 0.06 |
| 162 | 160.5 | -0.4 | 0.24 |
| 163 | 160.9 | 0.4 | 0.56 |
| 164 | 161.8 | 0.9 | 0.72 |
| 165 | 163.4 | 1.6 | 0.7 |
| 166 | 164.5 | 1.1 | 0.56 |
| 167 | 164 | -0.5 | 0.28 |
| 168 | 163.7 | -0.3 | -0.12 |
| 169 | 163.2 | -0.5 | -0.38 |
| 170 | 162.8 | -0.4 | -0.28 |

| Name | X | Y | Ele. (m) | DMEER |
|---|---|---|---|---|
| Kaarina | 60.4360 | 22.4323 | 38 | Sarmatic mixed forests |

| 2011 HBNF | Day | Weight (KG) |
|---|---|---|
| NF Start | 179 | 33.3 |
| NF End | 218 | 60 |
| NF Duration | 39 | 26.7 |
| Quarter | | 6.675 |
| 25% Flow | 183 | 39.975 |
| 50% Flow | 188 | 46.65 |
| 75% Flow | 193 | 53.325 |



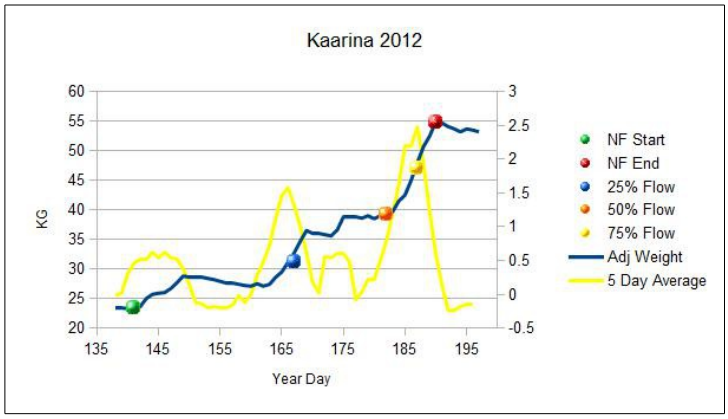

| 2011 NDVI | Day | | Value |
|---|---|---|---|
| SOS | 97.12 | Base val | 3928 |
| End | 319.2 | Peak val | 7021 |
| Length | 222.08 | Ampl. | 3093 |
| Peak t | 180.48 | L.deriv. | 1269 |
| | | R.deriv. | 408.1 |
| | | L.integral | 90300 |
| | | S.integral | 31380 |



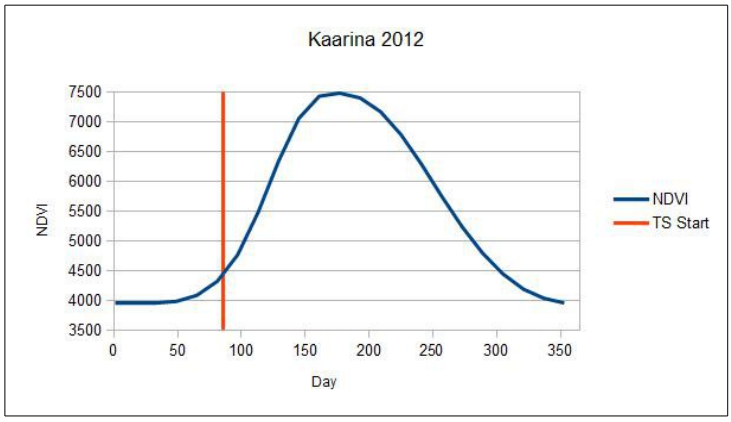

| 2011 | | | |
|---|---|---|---|
| Day | Adj KG | Adj Day | 5 Day Avg |
| 167 | 36.6 | -0.2 | -0.2 |
| 168 | 36.3 | -0.3 | -0.26 |
| 169 | 36.1 | -0.2 | -0.26 |
| 170 | 35.8 | -0.3 | -0.32 |
| 171 | 35.5 | -0.3 | -0.3 |
| 172 | 35 | -0.5 | -0.32 |
| 173 | 34.8 | -0.2 | -0.3 |
| 174 | 34.5 | -0.3 | -0.38 |
| 175 | 34.3 | -0.2 | -0.3 |
| 176 | 33.6 | -0.7 | -0.3 |
| 177 | 33.5 | -0.1 | -0.24 |
| 178 | 33.3 | -0.2 | 0.18 |
| 179 | 33.3 | 0 | 0.7 |
| 180 | 35.2 | 1.9 | 1.26 |
| 181 | 37.1 | 1.9 | 1.56 |
| 182 | 39.8 | 2.7 | 1.76 |
| 183 | 41.1 | 1.3 | 1.64 |
| 184 | 42.1 | 1 | 1.52 |
| 185 | 43.4 | 1.3 | 1.2 |
| 186 | 44.7 | 1.3 | 1.28 |
| 187 | 45.8 | 1.1 | 1.58 |
| 188 | 47.5 | 1.7 | 1.48 |
| 189 | 50 | 2.5 | 1.48 |
| 190 | 50.8 | 0.8 | 1.48 |
| 191 | 52.1 | 1.3 | 1.3 |
| 192 | 53.2 | 1.1 | 0.84 |
| 193 | 54 | 0.8 | 0.72 |
| 194 | 54.2 | 0.2 | 0.6 |
| 195 | 54.4 | 0.2 | 0.38 |
| 196 | 55.1 | 0.7 | 0.36 |
| 199 | 55.1 | 0 | 0.44 |
| 200 | 55.8 | 0.7 | 0.46 |
| 201 | 56.4 | 0.6 | 0.38 |
| 202 | 56.7 | 0.3 | 0.42 |
| 203 | 57 | 0.3 | 0.28 |
| 204 | 57.2 | 0.2 | 0.12 |
| 205 | 57.2 | 0 | 0.06 |
| 206 | 57 | -0.2 | 0.04 |
| 207 | 57 | 0 | 0.12 |
| 208 | 57.2 | 0.2 | 0.16 |
| 209 | 57.8 | 0.6 | 0.26 |
| 210 | 58 | 0.2 | 0.3 |
| 211 | 58.3 | 0.3 | 0.28 |
| 212 | 58.5 | 0.2 | 0.2 |
| 213 | 58.6 | 0.1 | 0.2 |
| 214 | 58.8 | 0.2 | 0.22 |
| 215 | 59 | 0.2 | 0.24 |
| 216 | 59.4 | 0.4 | 0.28 |
| 217 | 59.7 | 0.3 | 0.24 |
| 218 | 60 | 0.3 | 0.2 |
| 219 | 60 | 0 | 0.1 |
| 220 | 60 | 0 | 0.02 |

| Name | X | Y | Ele. (m) | DMEER |
|---|---|---|---|---|
| Kaarina | 60.4360 | 22.4323 | 38 | Sarmatic mixed forests |

| 2012 | Day | Weight (KG) |
|---|---|---|
| NF Start | 141 | 23.4 |
| NF End | 190 | 54.9 |
| NF Duration | 49 | 31.5 |
| Quarter | | 7.875 |
| 25% Flow | 167 | 31.275 |
| 50% Flow | 182 | 39.15 |
| 75% Flow | 187 | 47.025 |



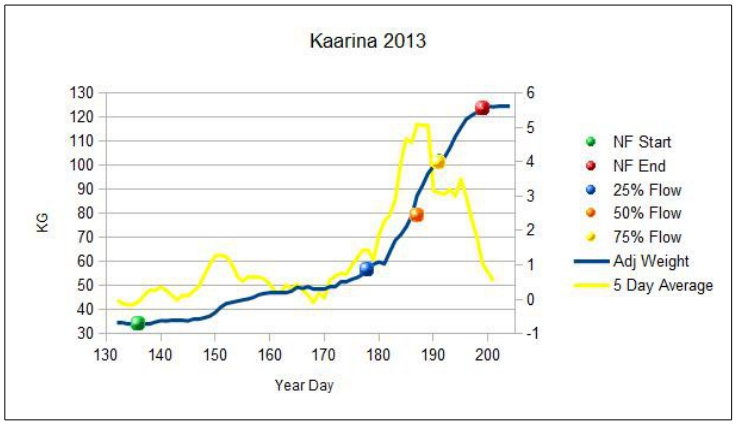

| 2012 NDVI | Day | | Value |
|---|---|---|---|
| SOS | 85.6 | Base val | 3937 |
| End | 303.04 | Peak val | 7478 |
| Length | 217.44 | Ampl. | 3541 |
| Peak t | 181.12 | L.deriv. | 741.7 |
| | | R.deriv. | 483 |
| | | L.integral | 90700 |
| | | S.integral | 31640 |



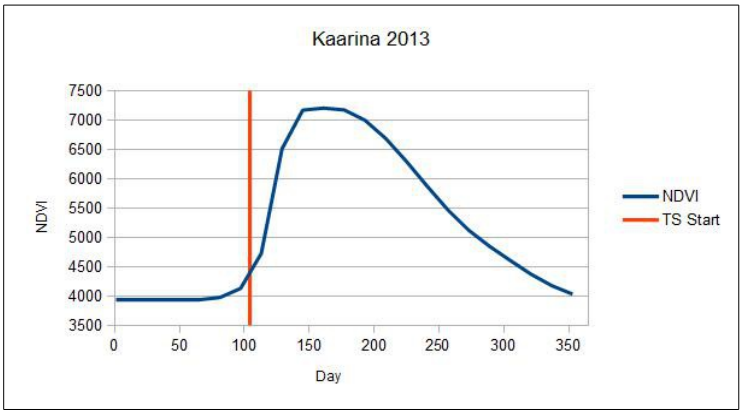

| 2012 | | | |
|---|---|---|---|
| Day | Adj KG | Adj Day | 5 Day Avg |
| 133 | 23.9 | 0 | 0 |
| 134 | 23.8 | -0.1 | 0 |
| 135 | 23.7 | -0.1 | 0 |
| 136 | 23.5 | -0.2 | -0.08 |
| 137 | 23.5 | 0 | -0.08 |
| 138 | 23.5 | 0 | -0.08 |
| 139 | 23.4 | -0.1 | -0.02 |
| 140 | 23.3 | -0.1 | 0.02 |
| 141 | 23.4 | 0.1 | 0.3 |
| 142 | 23.6 | 0.2 | 0.46 |
| 143 | 25 | 1.4 | 0.52 |
| 144 | 25.7 | 0.7 | 0.52 |
| 145 | 25.9 | 0.2 | 0.62 |
| 146 | 26 | 0.1 | 0.54 |
| 147 | 26.7 | 0.7 | 0.62 |
| 148 | 27.7 | 1 | 0.54 |
| 149 | 28.8 | 1.1 | 0.52 |
| 150 | 28.6 | -0.2 | 0.38 |
| 151 | 28.6 | 0 | 0.14 |
| 152 | 28.6 | 0 | -0.12 |
| 153 | 28.4 | -0.2 | -0.14 |
| 154 | 28.2 | -0.2 | -0.2 |
| 155 | 27.9 | -0.3 | -0.18 |
| 156 | 27.6 | -0.3 | -0.2 |
| 157 | 27.7 | 0.1 | -0.2 |
| 158 | 27.4 | -0.3 | -0.16 |
| 159 | 27.2 | -0.2 | -0.02 |
| 160 | 27.1 | -0.1 | -0.12 |
| 161 | 27.5 | 0.4 | 0 |
| 162 | 27.1 | -0.4 | 0.28 |
| 163 | 27.4 | 0.3 | 0.48 |
| 164 | 28.6 | 1.2 | 0.72 |
| 165 | 29.5 | 0.9 | 1.12 |
| 166 | 31.1 | 1.6 | 1.46 |
| 167 | 32.7 | 1.6 | 1.58 |
| 168 | 34.7 | 2 | 1.32 |
| 169 | 36.5 | 1.8 | 1 |
| 170 | 36.1 | -0.4 | 0.62 |
| 171 | 36.1 | 0 | 0.18 |
| 172 | 35.8 | -0.3 | 0.02 |
| 173 | 35.6 | -0.2 | 0.56 |
| 174 | 36.6 | 1 | 0.54 |
| 175 | 38.9 | 2.3 | 0.6 |
| 176 | 38.8 | -0.1 | 0.6 |
| 177 | 38.8 | 0 | 0.48 |
| 178 | 38.6 | -0.2 | -0.08 |
| 179 | 39 | 0.4 | 0.04 |
| 180 | 38.5 | -0.5 | 0.22 |
| 181 | 39 | 0.5 | 0.22 |
| 182 | 39.9 | 0.9 | 0.5 |
| 183 | 39.7 | -0.2 | 0.8 |
| 184 | 41.5 | 1.8 | 1.2 |
| 185 | 42.5 | 1 | 1.62 |
| 186 | 45 | 2.5 | 2.2 |
| 187 | 48 | 3 | 2.2 |
| 188 | 50.7 | 2.7 | 2.48 |
| 189 | 52.5 | 1.8 | 1.94 |
| 190 | 54.9 | 2.4 | 1.22 |
| 191 | 54.7 | -0.2 | 0.6 |
| 192 | 54.1 | -0.6 | 0.14 |
| 193 | 53.7 | -0.4 | -0.24 |
| 194 | 53.2 | -0.5 | -0.24 |
| 195 | 53.7 | 0.5 | -0.18 |
| 196 | 53.5 | -0.2 | -0.14 |

| Name | X | Y | Ele. (m) | DMEER |
|---|---|---|---|---|
| Kaarina | 60.4360 | 22.4323 | 38 | Sarmatic mixed forests |

| 2013 HBNF | Day | Weight (KG) |
|---|---|---|
| NF Start | 136 | 34 |
| NF End | 199 | 123.6 |
| NF Duration | 63 | 89.6 |
| Quarter | | 22.4 |
| 25% Flow | 178 | 56.4 |
| 50% Flow | 187 | 78.8 |
| 75% Flow | 191 | 101.2 |



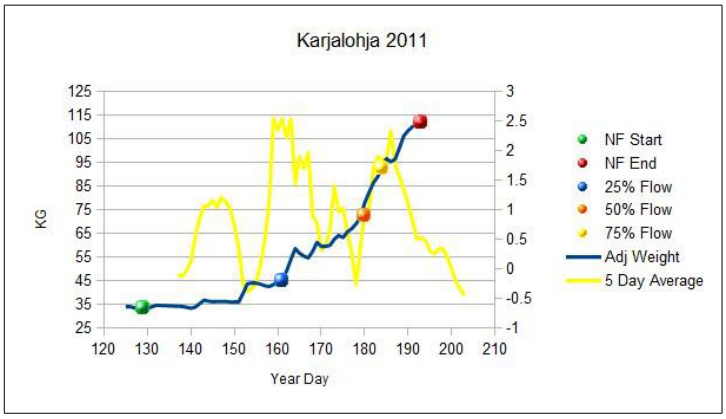

| 2013 NDVI | Day | | Value |
|---|---|---|---|
| SOS | 103.84 | Base val | 3912 |
| End | 318.56 | Peak val | 7202 |
| Length | 214.72 | Ampl. | 3290 |
| Peak t | 171.36 | L.deriv. | 1515 |
| | | R.deriv. | 339.9 |
| | | L.integral | 87140 |
| | | S.integral | 28470 |



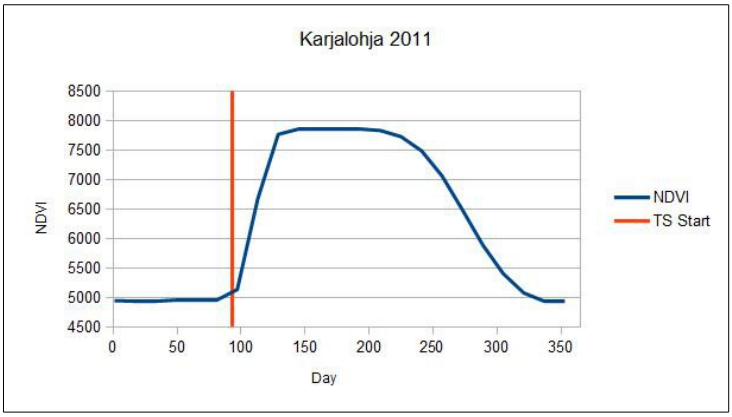

| 2013 | | | |
|---|---|---|---|
| Day | Adj KG | Adj Day | 5 Day Avg |
| 132 | 34.6 | -0.2 | -0.02 |
| 133 | 34.4 | -0.2 | -0.12 |
| 134 | 34.2 | -0.2 | -0.16 |
| 135 | 34 | -0.2 | -0.14 |
| 136 | 34 | 0 | -0.06 |
| 137 | 33.9 | -0.1 | 0.12 |
| 138 | 34.1 | 0.2 | 0.28 |
| 139 | 34.8 | 0.7 | 0.26 |
| 140 | 35.4 | 0.6 | 0.36 |
| 141 | 35.3 | -0.1 | 0.26 |
| 142 | 35.7 | 0.4 | 0.12 |
| 143 | 35.4 | -0.3 | -0.02 |
| 144 | 35.4 | 0 | 0.12 |
| 145 | 35.3 | -0.1 | 0.1 |
| 146 | 35.9 | 0.6 | 0.24 |
| 147 | 36.2 | 0.3 | 0.38 |
| 148 | 36.6 | 0.4 | 0.7 |
| 149 | 37.3 | 0.7 | 1.02 |
| 150 | 38.8 | 1.5 | 1.26 |
| 151 | 41 | 2.2 | 1.28 |
| 152 | 42.5 | 1.5 | 1.24 |
| 153 | 43 | 0.5 | 1.04 |
| 154 | 43.5 | 0.5 | 0.68 |
| 155 | 44 | 0.5 | 0.52 |
| 156 | 44.4 | 0.4 | 0.64 |
| 157 | 45.1 | 0.7 | 0.64 |
| 158 | 46.2 | 1.1 | 0.64 |
| 159 | 46.7 | 0.5 | 0.58 |
| 160 | 47.2 | 0.5 | 0.44 |
| 161 | 47.3 | 0.1 | 0.22 |
| 162 | 47.3 | 0 | 0.2 |
| 163 | 47.3 | 0 | 0.42 |
| 164 | 47.7 | 0.4 | 0.3 |
| 165 | 49.3 | 1.6 | 0.44 |
| 166 | 48.8 | -0.5 | 0.28 |
| 167 | 49.5 | 0.7 | 0.12 |
| 168 | 48.7 | -0.8 | -0.1 |
| 169 | 48.3 | -0.4 | 0.18 |
| 170 | 48.8 | 0.5 | 0.04 |
| 171 | 49.7 | 0.9 | 0.56 |
| 172 | 49.7 | 0 | 0.68 |
| 173 | 51.5 | 1.8 | 0.76 |
| 174 | 51.7 | 0.2 | 0.72 |
| 175 | 52.6 | 0.9 | 0.98 |
| 176 | 53.3 | 0.7 | 1.2 |
| 177 | 54.6 | 1.3 | 1.42 |
| 178 | 57.5 | 2.9 | 1.44 |
| 179 | 58.8 | 1.3 | 1.14 |
| 180 | 59.8 | 1 | 1.88 |
| 181 | 59 | -0.8 | 2.26 |
| 182 | 64 | 5 | 2.46 |
| 183 | 68.8 | 4.8 | 2.9 |
| 184 | 71.1 | 2.3 | 3.96 |
| 185 | 74.3 | 3.2 | 4.68 |
| 186 | 78.8 | 4.5 | 4.56 |
| 187 | 87.4 | 8.6 | 5.1 |
| 188 | 91.6 | 4.2 | 5.06 |
| 189 | 96.6 | 5 | 5.06 |
| 190 | 99.6 | 3 | 3.16 |
| 191 | 104.1 | 4.5 | 3.1 |
| 192 | 103.2 | -0.9 | 3.06 |
| 193 | 107.1 | 3.9 | 3.2 |
| 194 | 111.9 | 4.8 | 3 |
| 195 | 115.6 | 3.7 | 3.5 |
| 196 | 119.1 | 3.5 | 3 |
| 197 | 120.7 | 1.6 | 2.34 |
| 198 | 122.1 | 1.4 | 1.78 |
| 199 | 123.6 | 1.5 | 1.04 |
| 200 | 124.5 | 0.9 | 0.78 |
| 201 | 124.3 | -0.2 | 0.54 |
| 202 | 124.6 | 0.3 | 0.2 |

| Name | X | Y | Ele. (m) | DMEER |
|---|---|---|---|---|
| Karjalohja | 60.1834 | 23.6518 | 53 | Scandinavian and Russian taiga |

| **2011 HBNF** | Day | Weight (KG) |
|---|---|---|
| NF Start | 129 | 33.26 |
| NF End | 193 | 112.15 |
| NF Duration | 64 | 78.89 |
| Quarter | | 19.7225 |
| 25% Flow | 163 | 52.9825 |
| 50% Flow | 180 | 72.705 |
| 75% Flow | 184 | 92.4275 |



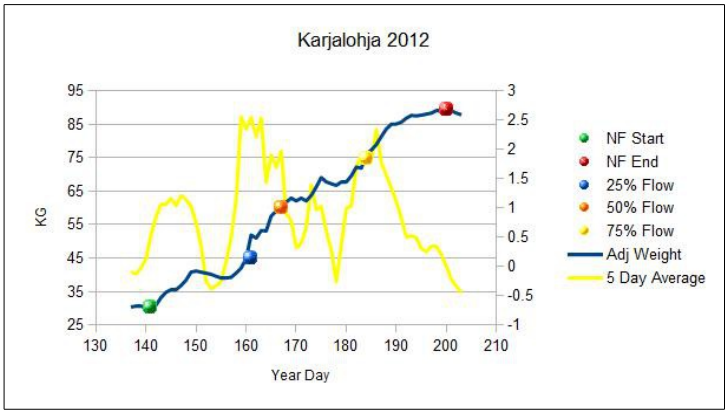

| **2011 NDVI** | Day | | Value |
|---|---|---|---|
| SOS | 98.56 | Base val | 4936 |
| End | 305.44 | Peak val | 7862 |
| Length | 206.88 | Ampl. | 2926 |
| Peak t | 184.48 | L.deriv. | 1348 |
| | | R.deriv. | 539.3 |
| | | L.integral | 104000 |
| | | S.integral | 29910 |



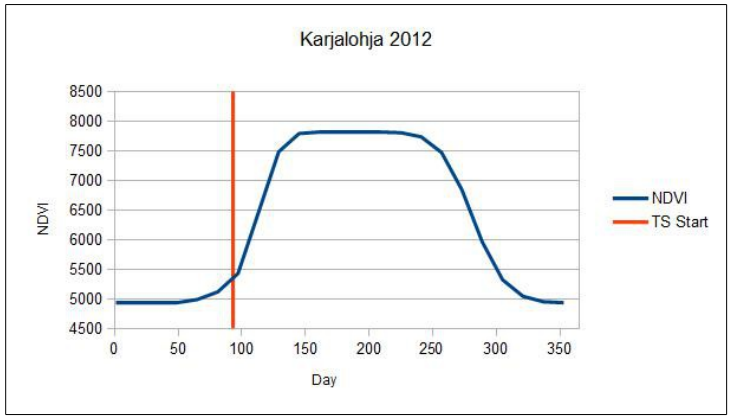

| 2011 | | | |
|---|---|---|---|
| Day | Adj KG | Adj Day | 5 Day Avg |
| 125 | 34.06 | -0.13 | -0.19 |
| 126 | 33.84 | -0.22 | -0.194 |
| 127 | 33.47 | -0.37 | -0.186 |
| 128 | 33.28 | -0.19 | -0.144 |
| 129 | 33.26 | -0.02 | 0.028 |
| 130 | 33.34 | 0.08 | 0.234 |
| 131 | 33.98 | 0.64 | 0.17 |
| 132 | 34.64 | 0.66 | 0.024 |
| 138 | 34.13 | -0.51 | 0.106 |
| 140 | 33.38 | -0.75 | 0.266 |
| 141 | 33.87 | 0.49 | 0.432 |
| 142 | 35.31 | 1.44 | 0.534 |
| 143 | 36.8 | 1.49 | 0.6 |
| 143 | 36.8 | 0 | 0.458 |
| 144 | 36.38 | -0.42 | 0.198 |
| 145 | 36.16 | -0.22 | -0.14 |
| 148 | 36.3 | 0.14 | -0.152 |
| 149 | 36.1 | -0.2 | -0.038 |
| 150 | 36.04 | -0.06 | 0.698 |
| 151 | 36.19 | 0.15 | 1.486 |
| 152 | 39.65 | 3.46 | 1.566 |
| 153 | 43.73 | 4.08 | 1.608 |
| 154 | 43.93 | 0.2 | 1.472 |
| 155 | 44.08 | 0.15 | 0.652 |
| 156 | 43.55 | -0.53 | -0.238 |
| 157 | 42.91 | -0.64 | -0.108 |
| 158 | 42.54 | -0.37 | 0.122 |
| 159 | 43.39 | 0.85 | 0.49 |
| 160 | 44.69 | 1.3 | 1.216 |
| 161 | 46 | 1.31 | 2.294 |
| 162 | 48.99 | 2.99 | 3.04 |
| 163 | 54.01 | 5.02 | 2.388 |
| 164 | 58.59 | 4.58 | 1.882 |
| 165 | 56.63 | -1.96 | 1.132 |
| 166 | 55.41 | -1.22 | 0.688 |
| 167 | 54.65 | -0.76 | 0.526 |
| 168 | 57.45 | 2.8 | 0.582 |
| 169 | 61.22 | 3.77 | 0.8 |
| 170 | 59.54 | -1.68 | 1.07 |
| 171 | 59.41 | -0.13 | 1.02 |
| 172 | 60 | 0.59 | 0.584 |
| 173 | 62.55 | 2.55 | 0.752 |
| 174 | 64.14 | 1.59 | 1.248 |
| 175 | 63.3 | -0.84 | 1.404 |
| 176 | 65.65 | 2.35 | 1.3 |
| 177 | 67.02 | 1.37 | 1.524 |
| 178 | 69.05 | 2.03 | 2.938 |
| 179 | 71.76 | 2.71 | 3.346 |
| 180 | 77.99 | 6.23 | 3.888 |
| 181 | 82.38 | 4.39 | 3.994 |
| 182 | 86.46 | 4.08 | 4.252 |
| 183 | 89.02 | 2.56 | 3.744 |
| 184 | 93.02 | 4 | 2.59 |
| 185 | 96.71 | 3.69 | 1.99 |
| 186 | 95.33 | -1.38 | 2.44 |
| 187 | 96.41 | 1.08 | 2.66 |
| 188 | 101.22 | 4.81 | 2.366 |
| 189 | 106.32 | 5.1 | 2.972 |
| 190 | 108.54 | 2.22 | 2.94 |
| 191 | 110.19 | 1.65 | 2.186 |
| 192 | 111.11 | 0.92 | 1.062 |
| 193 | 112.15 | 1.04 | 0.64 |
| 194 | 111.63 | -0.52 | 0.414 |

| Name | X | Y | Ele. (m) | DMEER |
|---|---|---|---|---|
| Karjalohja | 60.1834 | 23.6518 | 53 | Scandinavian and Russian taiga |

| 2012 HBNF | Day | Weight (KG) |
|---|---|---|
| NF Start | 141 | 30.285 |
| NF End | 200 | 89.43 |
| NF Duration | 59 | 59.145 |
| Quarter | | 14.78625 |
| 25% Flow | 161 | 45.07125 |
| 50% Flow | 167 | 59.8575 |
| 75% Flow | 184 | 74.64375 |



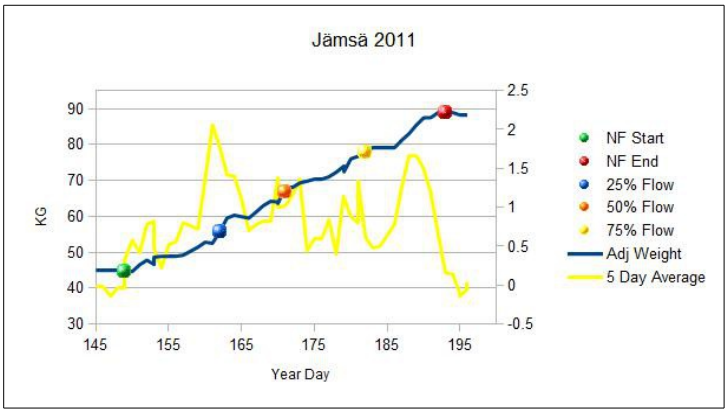

| 2012 HBNF | Day | | Value |
|---|---|---|---|
| SOS | 92.64 | Base val | 4928 |
| End | 303.04 | Peak val | 7822 |
| Length | 210.24 | Ampl. | 2894 |
| Peak t | 192.96 | L.deriv. | 1027 |
| | | R.deriv. | 739.1 |
| | | L.integral | 104700 |
| | | S.integral | 30750 |



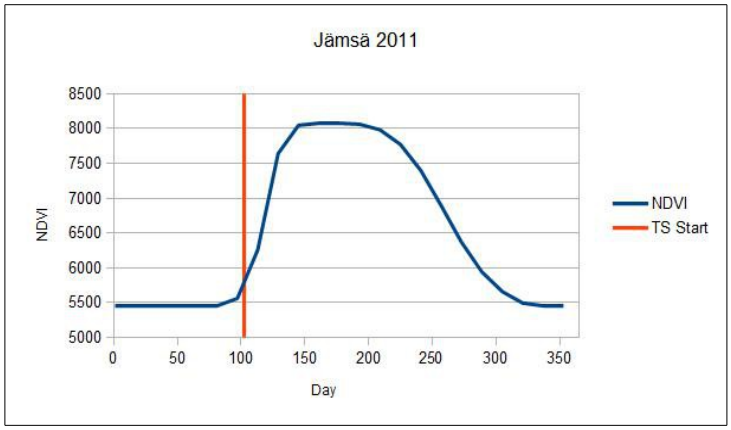

| 2012 | | | |
|---|---|---|---|
| Day | Adj KG | Adj Day | 5 Day Avg |
| 137 | 30.335 | -0.08 | -0.094 |
| 138 | 30.48 | 0.145 | -0.129 |
| 139 | 30.5 | 0.02 | -0.026 |
| 140 | 30.075 | -0.425 | 0.126 |
| 141 | 30.285 | 0.21 | 0.541 |
| 142 | 30.965 | 0.68 | 0.85 |
| 143 | 33.185 | 2.22 | 1.067 |
| 144 | 34.75 | 1.565 | 1.07 |
| 145 | 35.41 | 0.66 | 1.162 |
| 146 | 35.635 | 0.225 | 1.04 |
| 147 | 36.775 | 1.14 | 1.211 |
| 148 | 38.385 | 1.61 | 1.14 |
| 149 | 40.805 | 2.42 | 1.028 |
| 150 | 41.11 | 0.305 | 0.74 |
| 151 | 40.775 | -0.335 | 0.35 |
| 152 | 40.475 | -0.3 | -0.251 |
| 153 | 40.135 | -0.34 | -0.384 |
| 154 | 39.55 | -0.585 | -0.332 |
| 155 | 39.19 | -0.36 | -0.251 |
| 156 | 39.115 | -0.075 | 0.076 |
| 157 | 39.22 | 0.105 | 0.49 |
| 158 | 40.515 | 1.295 | 1.134 |
| 159 | 42 | 1.485 | 2.552 |
| 160 | 44.86 | 2.86 | 2.347 |
| 161 | 51.875 | 7.015 | 2.542 |
| 162 | 50.955 | -0.92 | 2.218 |
| 163 | 53.225 | 2.27 | 2.537 |
| 164 | 53.09 | -0.135 | 1.433 |
| 165 | 57.545 | 4.455 | 1.905 |
| 166 | 59.04 | 1.495 | 1.697 |
| 167 | 60.48 | 1.44 | 1.971 |
| 168 | 61.71 | 1.23 | 0.908 |
| 169 | 62.945 | 1.235 | 0.779 |
| 170 | 62.085 | -0.86 | 0.322 |
| 171 | 62.935 | 0.85 | 0.4 |
| 172 | 62.09 | -0.845 | 0.661 |
| 173 | 63.71 | 1.62 | 1.399 |
| 174 | 66.25 | 2.54 | 0.97 |
| 175 | 69.08 | 2.83 | 1.027 |
| 176 | 67.785 | -1.295 | 0.605 |
| 177 | 67.225 | -0.56 | 0.274 |
| 178 | 66.735 | -0.49 | -0.261 |
| 179 | 67.62 | 0.885 | 0.357 |
| 180 | 67.775 | 0.155 | 0.993 |
| 181 | 69.57 | 1.795 | 1.029 |
| 182 | 72.19 | 2.62 | 1.703 |
| 183 | 71.88 | -0.31 | 1.902 |
| 184 | 76.135 | 4.255 | 1.868 |
| 185 | 77.285 | 1.15 | 1.822 |
| 186 | 78.91 | 1.625 | 2.338 |
| 187 | 81.3 | 2.39 | 1.774 |
| 188 | 83.57 | 2.27 | 1.559 |
| 189 | 85.005 | 1.435 | 1.343 |
| 190 | 85.08 | 0.075 | 1.103 |
| 191 | 85.625 | 0.545 | 0.819 |
| 192 | 86.815 | 1.19 | 0.499 |
| 193 | 87.665 | 0.85 | 0.528 |
| 194 | 87.5 | -0.165 | 0.483 |
| 195 | 87.72 | 0.22 | 0.304 |
| 196 | 88.04 | 0.32 | 0.254 |
| 197 | 88.335 | 0.295 | 0.344 |
| 198 | 88.935 | 0.6 | 0.342 |
| 199 | 89.22 | 0.285 | 0.201 |
| 200 | 89.43 | 0.21 | 0.001 |
| 201 | 89.045 | -0.385 | -0.223 |

| Name | X | Y | Ele. (m) | DMEER |
|---|---|---|---|---|
| Jämsä | 61.9642 | 25.3007 | 117 | Scandinavian and Russian taiga |

| HBNF 2011 | Day | Weight (KG) |
|---|---|---|
| NF Start | 149 | 44.7 |
| NF End | 193 | 88.9 |
| NF Duration | 44 | 44.2 |
| Quarter | | 11.05 |
| 25% Flow | 162 | 55.75 |
| 50% Flow | 171 | 66.8 |
| 75% Flow | 182 | 77.85 |



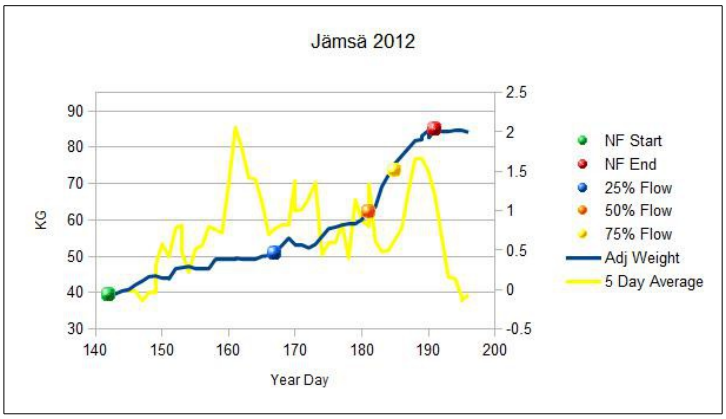

| 2011 NDVI | Day | | Value |
|---|---|---|---|
| SOS | 102.56 | Base val | 5450 |
| End | 293.28 | Peak val | 8075 |
| Length | 190.72 | Ampl. | 2625 |
| Peak t | 180.16 | L.deriv. | 1177 |
| | | R.deriv. | 474.3 |
| | | L.integral | 99710 |
| | | S.integral | 23410 |



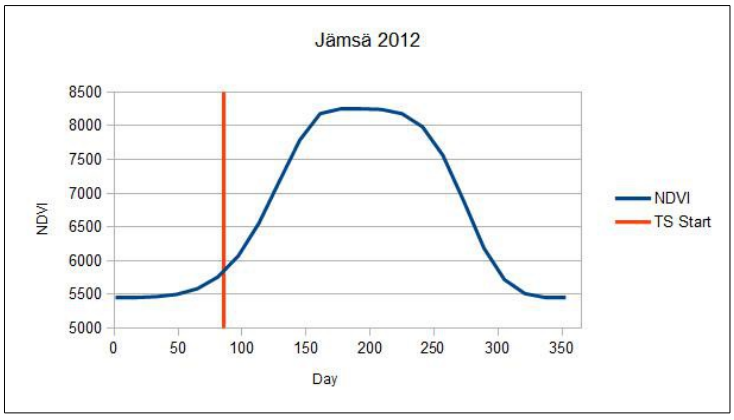

| 2011 | | | |
|---|---|---|---|
| Day | Adj KG | Adj Day | 5 Day Avg |
| 145 | 44.9 | -0.3 | -0.02 |
| 146 | 44.9 | 0 | -0.02 |
| 147 | 44.9 | 0 | -0.14 |
| 148 | 44.9 | 0 | -0.04 |
| 149 | 44.5 | -0.4 | -0.04 |
| 149 | 44.7 | 0.2 | 0.32 |
| 150 | 44.7 | 0 | 0.58 |
| 151 | 46.5 | 1.8 | 0.42 |
| 152 | 47.8 | 1.3 | 0.78 |
| 153 | 46.6 | -1.2 | 0.82 |
| 153 | 48.6 | 2 | 0.48 |
| 154 | 48.8 | 0.2 | 0.22 |
| 155 | 48.9 | 0.1 | 0.52 |
| 156 | 48.9 | 0 | 0.56 |
| 157 | 49.2 | 0.3 | 0.8 |
| 159 | 51.4 | 2.2 | 0.72 |
| 160 | 52.8 | 1.4 | 1.36 |
| 161 | 52.5 | -0.3 | 2.06 |
| 162 | 55.7 | 3.2 | 1.78 |
| 163 | 59.5 | 3.8 | 1.42 |
| 164 | 60.3 | 0.8 | 1.4 |
| 165 | 59.9 | -0.4 | 1.1 |
| 166 | 59.5 | -0.4 | 0.7 |
| 167 | 61.2 | 1.7 | 0.78 |
| 168 | 63 | 1.8 | 0.82 |
| 169 | 64.2 | 1.2 | 0.82 |
| 170 | 64 | -0.2 | 1.38 |
| 170 | 63.6 | -0.4 | 1 |
| 171 | 68.1 | 4.5 | 1.02 |
| 172 | 68 | -0.1 | 1.16 |
| 173 | 69.3 | 1.3 | 1.36 |
| 174 | 69.8 | 0.5 | 0.44 |
| 175 | 70.4 | 0.6 | 0.6 |
| 176 | 70.3 | -0.1 | 0.6 |
| 177 | 71 | 0.7 | 0.84 |
| 178 | 72.3 | 1.3 | 0.4 |
| 179 | 74 | 1.7 | 1.14 |
| 179 | 72.4 | -1.6 | 1.14 |
| 180 | 76 | 3.6 | 0.88 |
| 181 | 76.7 | 0.7 | 0.8 |
| 181 | 76.7 | 0 | 1.34 |
| 182 | 78 | 1.3 | 0.62 |
| 183 | 79.1 | 1.1 | 0.48 |
| 184 | 79.1 | 0 | 0.5 |
| 185 | 79.1 | 0 | 0.64 |
| 186 | 79.2 | 0.1 | 0.78 |
| 187 | 81.2 | 2 | 1.26 |
| 188 | 83 | 1.8 | 1.66 |
| 189 | 85.4 | 2.4 | 1.66 |
| 190 | 87.4 | 2 | 1.5 |
| 191 | 87.5 | 0.1 | 1.18 |
| 192 | 88.7 | 1.2 | 0.66 |
| 193 | 88.9 | 0.2 | 0.16 |
| 194 | 88.7 | -0.2 | 0.14 |
| 195 | 88.2 | -0.5 | -0.1 |
| 196 | 88.2 | 0 | -0.06 |

| Name | X | Y | Ele. (m) | DMEER |
|---|---|---|---|---|
| Jämsä | 61.9642 | 25.3007 | 117 | Scandinavian and Russian taiga |

| 2012 HBNF | Day | Weight (KG) |
|---|---|---|
| NF Start | 142 | 39.4 |
| NF End | 191 | 85 |
| NF Duration | 49 | 45.6 |
| Quarter | | 11.4 |
| 25% Flow | 167 | 50.8 |
| 50% Flow | 181 | 62.2 |
| 75% Flow | 185 | 73.6 |



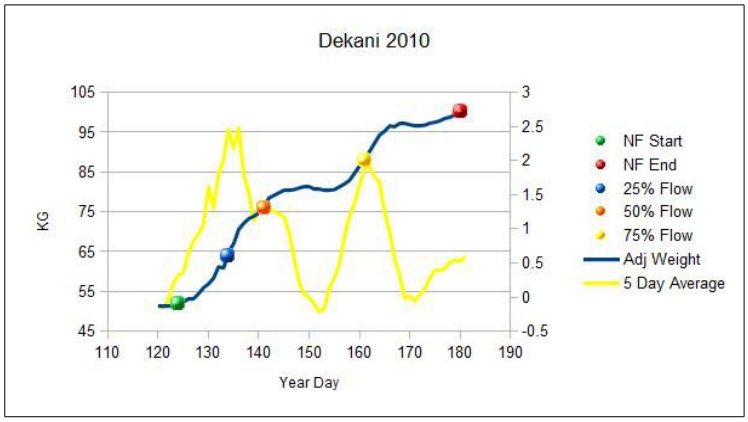

| 2012 NDVI | Day | | Value |
|---|---|---|---|
| SOS | 85.92 | Base val | 5450 |
| End | 298.72 | Peak val | 8257 |
| Length | 212.8 | Ampl. | 2806 |
| Peak t | 196.32 | L.deriv. | 555 |
| | | R.deriv. | 625.6 |
| | | L.integral | 108800 |
| | | S.integral | 27020 |



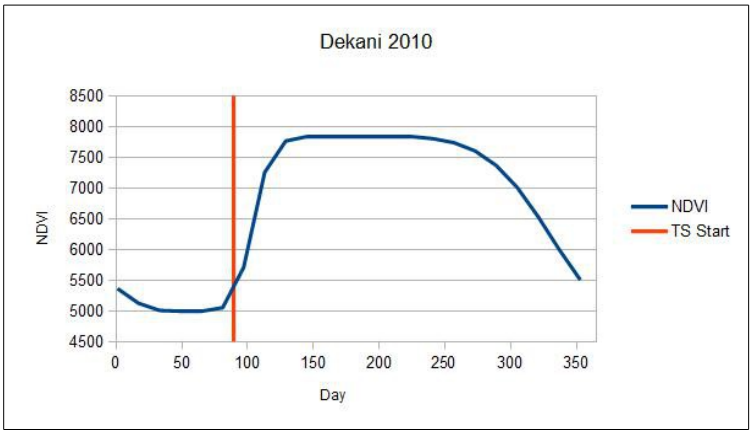

| 2012 | | | |
|---|---|---|---|
| Day | Adj KG | Adj Day | 5 Day Avg |
| 142 | 39.4 | 0.8 | 0.6333333333 |
| 143 | 39.7 | 0.3 | 0.575 |
| 144 | 40.5 | 0.8 | 0.72 |
| 145 | 40.9 | 0.4 | 0.76 |
| 146 | 42.2 | 1.3 | 0.94 |
| 147 | 43.2 | 1 | 0.82 |
| 148 | 44.4 | 1.2 | 0.64 |
| 149 | 44.6 | 0.2 | 0.36 |
| 150 | 44.1 | -0.5 | 0.12 |
| 151 | 44 | -0.1 | 0.44 |
| 151 | 43.8 | -0.2 | 0.52 |
| 152 | 46.6 | 2.8 | 0.52 |
| 154 | 47.2 | 0.6 | 0.54 |
| 155 | 46.7 | -0.5 | 0.58 |
| 156 | 46.7 | 0 | 0.54 |
| 157 | 46.7 | 0 | 0.42 |
| 158 | 49.3 | 2.6 | 0.52 |
| 159 | 49.3 | 0 | 0.52 |
| 160 | 49.3 | 0 | 0.56 |
| 161 | 49.3 | 0 | 0 |
| 161 | 49.5 | 0.2 | 0 |
| 162 | 49.3 | -0.2 | 0 |
| 163 | 49.3 | 0 | 0.14 |
| 164 | 49.3 | 0 | 0.14 |
| 165 | 50 | 0.7 | 0.36 |
| 166 | 50.2 | 0.2 | 1.14 |
| 167 | 51.1 | 0.9 | 0.74 |
| 169 | 55 | 3.9 | 0.6 |
| 170 | 53 | -2 | 0.42 |
| 171 | 53 | 0 | 0.44 |
| 172 | 52.3 | -0.7 | 0.52 |
| 173 | 53.3 | 1 | 1 |
| 175 | 57.6 | 4.3 | 1.12 |
| 176 | 58 | 0.4 | 1.36 |
| 177 | 58.6 | 0.6 | 1.16 |
| 178 | 59.1 | 0.5 | 0.5 |
| 179 | 59.1 | 0 | 1 |
| 180 | 60.1 | 1 | 0.98 |
| 181 | 63 | 2.9 | 2.02 |
| 182 | 63.5 | 0.5 | 2.66 |
| 183 | 69.2 | 5.7 | 3.1 |
| 184 | 72.4 | 3.2 | 3.76 |
| 185 | 75.6 | 3.2 | 3.72 |
| 188 | 81.8 | 6.2 | 2.78 |
| 189 | 82.1 | 0.3 | 2.46 |
| 189 | 83.1 | 1 | 1.4 |
| 190 | 84.7 | 1.6 | 0.64 |
| 190 | 82.6 | -2.1 | 0.46 |
| 191 | 85 | 2.4 | 0.24 |
| 192 | 84.4 | -0.6 | -0.02 |
| 193 | 84.3 | -0.1 | 0.4 |
| 194 | 84.6 | 0.3 | -0.18 |
| 195 | 84.6 | 0 | -0.12 |
| 196 | 84.1 | -0.5 | 0.04 |

| Name | X | Y | Ele. (m) | DMEER |
|---|---|---|---|---|
| Koper – Dekani | 45.5414 | 13.8330 | 65 | Illyrian deciduous forests |

| **2010 HBNF** | Day | Weight (KG) |
|---|---|---|
| NF Start | 124 | 51.8 |
| NF End | 180 | 100.1 |
| NF Duration | 56 | 48.3 |
| Quarter | | 12.075 |
| 25% Flow | 134 | 63.875 |
| 50% Flow | 141 | 75.95 |
| 75% Flow | 161 | 88.025 |



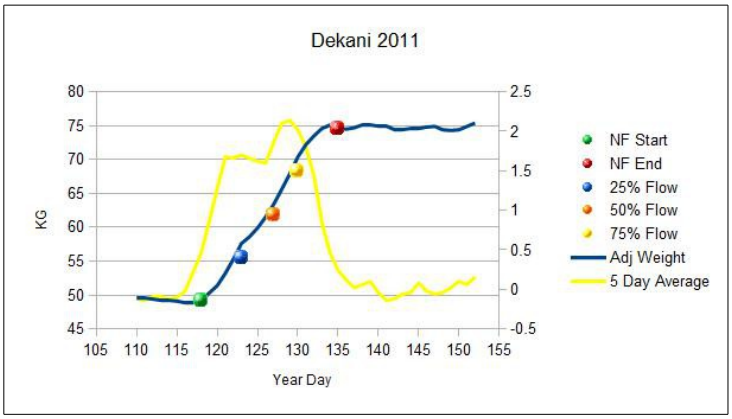

| **2010 NDVI** | Day | | Value |
|---|---|---|---|
| SOS | 89.12 | Base val | 4967 |
| End | 357.76 | Peak val | 7837 |
| Length | 268.64 | Ampl. | 2870 |
| Peak t | 202.56 | L.deriv. | 1369 |
| | | R.deriv. | 474.1 |
| | | L.integral | 133400 |
| | | S.integral | 39070 |



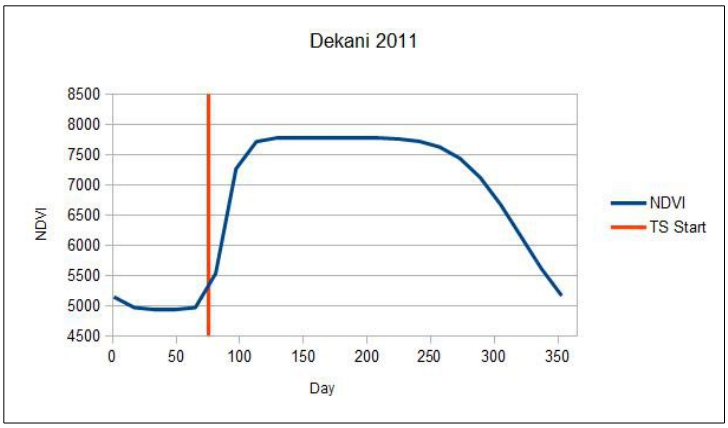

| 2010 | | | |
|---|---|---|---|
| Day | Adj KG | Adj Day | 5 Day Avg |
| 120 | 51.3 | -0.8 | -0.12 |
| 121 | 51.4 | 0.1 | -0.16 |
| 122 | 51.3 | -0.1 | -0.06 |
| 123 | 51.2 | -0.1 | 0.2 |
| 124 | 51.8 | 0.6 | 0.32 |
| 125 | 52.3 | 0.5 | 0.36 |
| 126 | 53 | 0.7 | 0.64 |
| 127 | 53.1 | 0.1 | 0.82 |
| 128 | 54.4 | 1.3 | 0.92 |
| 129 | 55.9 | 1.5 | 1.06 |
| 130 | 56.9 | 1 | 1.62 |
| 131 | 58.3 | 1.4 | 1.3 |
| 132 | 61.2 | 2.9 | 1.8 |
| 133 | 60.9 | -0.3 | 2.02 |
| 134 | 64.9 | 4 | 2.46 |
| 135 | 67 | 2.1 | 2.18 |
| 136 | 70.6 | 3.6 | 2.48 |
| 137 | 72.1 | 1.5 | 1.8 |
| 138 | 73.3 | 1.2 | 1.54 |
| 139 | 73.9 | 0.6 | 1.12 |
| 140 | 74.7 | 0.8 | 1.28 |
| 141 | 76.2 | 1.5 | 1.4 |
| 142 | 78.5 | 2.3 | 1.3 |
| 145 | 80.3 | 1.8 | 1.18 |
| 146 | 80.4 | 0.1 | 0.96 |
| 147 | 80.6 | 0.2 | 0.58 |
| 148 | 81 | 0.4 | 0.22 |
| 149 | 81.4 | 0.4 | 0.04 |
| 150 | 81.4 | 0 | 0 |
| 151 | 80.6 | -0.8 | -0.1 |
| 152 | 80.6 | 0 | -0.22 |
| 153 | 80.5 | -0.1 | -0.16 |
| 154 | 80.3 | -0.2 | 0.14 |
| 155 | 80.6 | 0.3 | 0.28 |
| 156 | 81.3 | 0.7 | 0.48 |
| 157 | 82 | 0.7 | 0.88 |
| 158 | 82.9 | 0.9 | 1.18 |
| 159 | 84.7 | 1.8 | 1.38 |
| 160 | 86.5 | 1.8 | 1.64 |
| 161 | 88.2 | 1.7 | 1.88 |
| 162 | 90.2 | 2 | 1.92 |
| 163 | 92.3 | 2.1 | 1.76 |
| 164 | 94.3 | 2 | 1.68 |
| 165 | 95.3 | 1 | 1.24 |
| 166 | 96.6 | 1.3 | 0.96 |
| 167 | 96.4 | -0.2 | 0.56 |
| 168 | 97.1 | 0.7 | 0.32 |
| 169 | 97.1 | 0 | -0.02 |
| 170 | 96.9 | -0.2 | 0.02 |
| 171 | 96.5 | -0.4 | -0.06 |
| 172 | 96.5 | 0 | 0.04 |
| 173 | 96.8 | 0.3 | 0.12 |
| 174 | 97.3 | 0.5 | 0.28 |
| 175 | 97.5 | 0.2 | 0.4 |
| 176 | 97.9 | 0.4 | 0.4 |
| 177 | 98.5 | 0.6 | 0.42 |
| 178 | 98.8 | 0.3 | 0.52 |
| 179 | 99.4 | 0.6 | 0.54 |
| 180 | 100.1 | 0.7 | 0.525 |

| Name | X | Y | Ele. (m) | DMEER |
|---|---|---|---|---|
| Koper – Dekani | 45.5414 | 13.8330 | 65 | Illyrian deciduous forests |

| 2011 HBNF | Day | Weight (KG) |
|---|---|---|
| NF Start | 118 | 49.2 |
| NF End | 135 | 74.6 |
| NF Duration | 17 | 25.4 |
| Quarter | | 6.35 |
| 25% Flow | 123 | 55.55 |
| 50% Flow | 127 | 61.9 |
| 75% Flow | 130 | 68.25 |



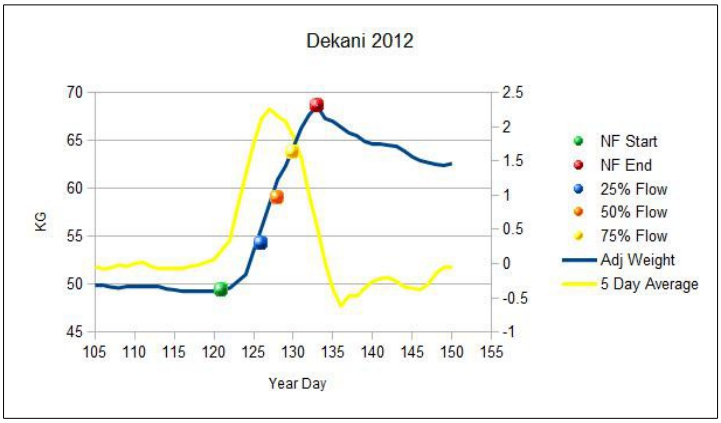

| 2011 NDVI | Day | | Value |
|---|---|---|---|
| SOS | 75.2 | Base val | 4758 |
| End | 357.28 | Peak val | 7774 |
| Length | 281.92 | Ampl. | 3016 |
| Peak t | 191.36 | L.deriv. | 1680 |
| | | R.deriv. | 487.5 |
| | | L.integral | 138200 |
| | | S.integral | 43040 |



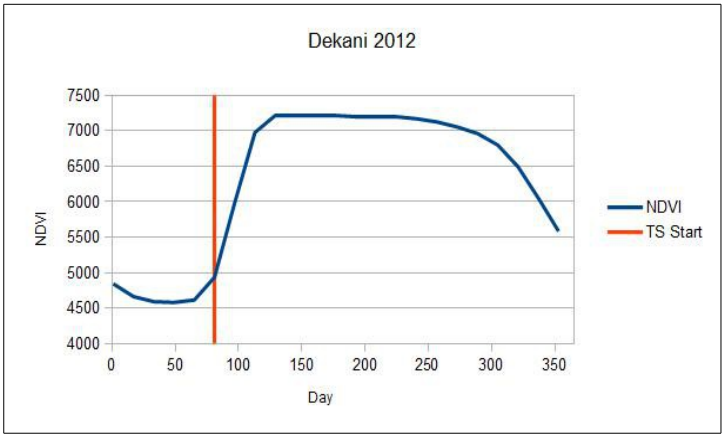

| 2011 | | | |
|---|---|---|---|
| Day | Adj KG | Adj Day | 5 Day Avg |
| 110 | 49.6 | -0.1 | -0.12 |
| 111 | 49.5 | -0.1 | -0.14 |
| 112 | 49.4 | -0.1 | -0.1 |
| 113 | 49.3 | -0.1 | -0.1 |
| 114 | 49.2 | -0.1 | -0.12 |
| 115 | 49.1 | -0.1 | -0.1 |
| 116 | 48.9 | -0.2 | -0.02 |
| 117 | 48.9 | 0 | 0.22 |
| 118 | 49.2 | 0.3 | 0.46 |
| 119 | 50.3 | 1.1 | 0.86 |
| 120 | 51.4 | 1.1 | 1.28 |
| 121 | 53.2 | 1.8 | 1.68 |
| 122 | 55.3 | 2.1 | 1.66 |
| 123 | 57.6 | 2.3 | 1.7 |
| 124 | 58.6 | 1 | 1.66 |
| 125 | 59.9 | 1.3 | 1.62 |
| 126 | 61.5 | 1.6 | 1.6 |
| 127 | 63.4 | 1.9 | 1.86 |
| 128 | 65.6 | 2.2 | 2.1 |
| 129 | 67.9 | 2.3 | 2.14 |
| 130 | 70.4 | 2.5 | 2.02 |
| 131 | 72.2 | 1.8 | 1.8 |
| 132 | 73.5 | 1.3 | 1.44 |
| 133 | 74.6 | 1.1 | 0.84 |
| 134 | 75.1 | 0.5 | 0.46 |
| 135 | 74.6 | -0.5 | 0.24 |
| 136 | 74.5 | -0.1 | 0.12 |
| 137 | 74.7 | 0.2 | 0.02 |
| 138 | 75.2 | 0.5 | 0.06 |
| 139 | 75.2 | 0 | 0.1 |
| 140 | 74.9 | -0.3 | -0.04 |
| 141 | 75 | 0.1 | -0.14 |
| 142 | 74.5 | -0.5 | -0.12 |
| 143 | 74.5 | 0 | -0.06 |
| 144 | 74.6 | 0.1 | -0.04 |
| 145 | 74.6 | 0 | 0.08 |
| 146 | 74.8 | 0.2 | -0.02 |
| 147 | 74.9 | 0.1 | -0.06 |
| 148 | 74.4 | -0.5 | -0.04 |
| 149 | 74.3 | -0.1 | 0.02 |
| 150 | 74.4 | 0.1 | 0.1 |
| 151 | 74.9 | 0.5 | 0.06 |
| 152 | 75.4 | 0.5 | 0.16 |

| Name | X | Y | Ele. (m) | DMEER |
|---|---|---|---|---|
| Koper – Dekani | 45.5414 | 13.8330 | 65 | Illyrian deciduous forests |

| **2012 HBNF** | Day | Weight (KG) |
|---|---|---|
| NF Start | 121 | 49.4 |
| NF End | 133 | 68.6 |
| NF Duration | 12 | 19.2 |
| Quarter | | 4.8 |
| 25% Flow | 126 | 54.2 |
| 50% Flow | 128 | 59 |
| 75% Flow | 130 | 63.8 |



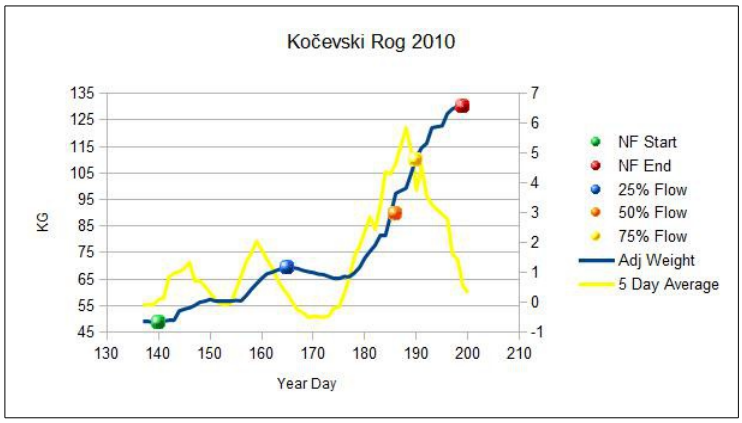

| **2012 NDVI** | Day | | Value |
|---|---|---|---|
| SOS | 80.64 | Base val | 4756 |
| End | 365.28 | Peak val | 7221 |
| Length | 284.64 | Ampl. | 2464 |
| Peak t | 206.56 | L.deriv. | 1023 |
| | | R.deriv. | 402.7 |
| | | L.integral | 126800 |
| | | S.integral | 36430 |



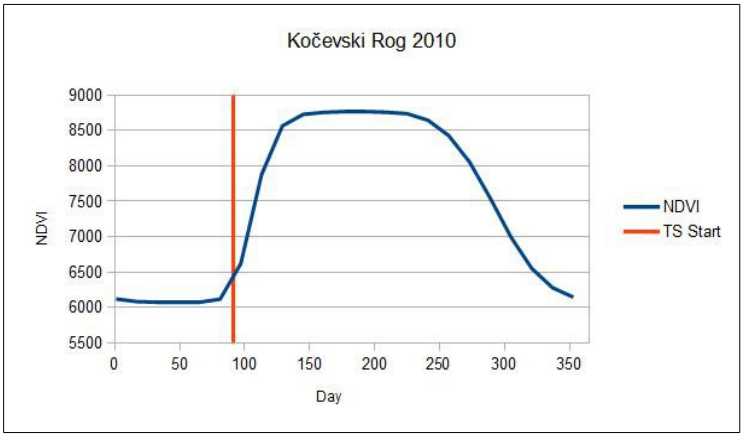

| 2012 | | | |
|---|---|---|---|
| Day | Adj KG | Adj Day | 5 Day Avg |
| 105 | 49.9 | -0.1 | -0.04 |
| 106 | 49.9 | 0 | -0.08 |
| 107 | 49.7 | -0.2 | -0.06 |
| 108 | 49.6 | -0.1 | -0.02 |
| 109 | 49.7 | 0.1 | -0.04 |
| 110 | 49.8 | 0.1 | 0 |
| 111 | 49.7 | -0.1 | 0.02 |
| 112 | 49.7 | 0 | -0.04 |
| 113 | 49.7 | 0 | -0.08 |
| 114 | 49.5 | -0.2 | -0.08 |
| 115 | 49.4 | -0.1 | -0.08 |
| 116 | 49.3 | -0.1 | -0.08 |
| 117 | 49.3 | 0 | -0.04 |
| 118 | 49.3 | 0 | -0.02 |
| 119 | 49.3 | 0 | 0.02 |
| 120 | 49.3 | 0 | 0.06 |
| 121 | 49.4 | 0.1 | 0.2 |
| 122 | 49.6 | 0.2 | 0.34 |
| 123 | 50.3 | 0.7 | 0.84 |
| 124 | 51 | 0.7 | 1.3 |
| 125 | 53.5 | 2.5 | 1.76 |
| 126 | 55.9 | 2.4 | 2.12 |
| 127 | 58.4 | 2.5 | 2.26 |
| 128 | 60.9 | 2.5 | 2.16 |
| 129 | 62.3 | 1.4 | 2.08 |
| 130 | 64.3 | 2 | 1.86 |
| 131 | 66.3 | 2 | 1.54 |
| 132 | 67.7 | 1.4 | 1 |
| 133 | 68.6 | 0.9 | 0.54 |
| 134 | 67.3 | -1.3 | 0.02 |
| 135 | 67 | -0.3 | -0.38 |
| 136 | 66.4 | -0.6 | -0.62 |
| 137 | 65.8 | -0.6 | -0.48 |
| 138 | 65.5 | -0.3 | -0.48 |
| 139 | 64.9 | -0.6 | -0.36 |
| 140 | 64.6 | -0.3 | -0.26 |
| 141 | 64.6 | 0 | -0.22 |
| 142 | 64.5 | -0.1 | -0.2 |
| 143 | 64.4 | -0.1 | -0.26 |
| 144 | 63.9 | -0.5 | -0.34 |

| Name | X | Y | Ele. (m) | DMEER |
|---|---|---|---|---|
| Kočevski Rog | 45.7086 | 15.0293 | 535 | Pannonian mixed forests |

| 2010 HBNF | Day | Weight (KG) |
|---|---|---|
| NF Start | 140 | 48.8 |
| NF End | 199 | 130.2 |
| NF Duration | 59 | 81.4 |
| Quarter | | 20.35 |
| 25% Flow | 165 | 69.15 |
| 50% Flow | 186 | 89.5 |
| 75% Flow | 190 | 109.85 |



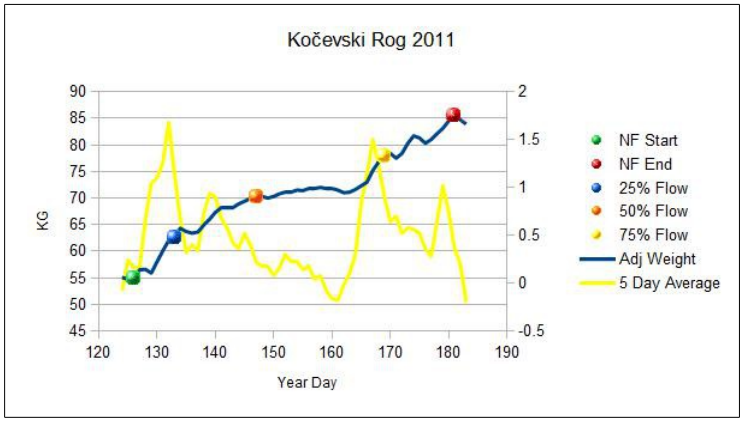

| 2010 NDVI | Year Day | | Value |
|---|---|---|---|
| SOS | 91.36 | Base val | 6075 |
| End | 324 | Peak val | 8760 |
| Length | 192.48 | Ampl. | 2685 |
| Peak t | 208.48 | L.deriv. | 1059 |
| | | R.deriv. | 487.2 |
| | | L.integral | 134200 |
| | | S.integral | 30900 |



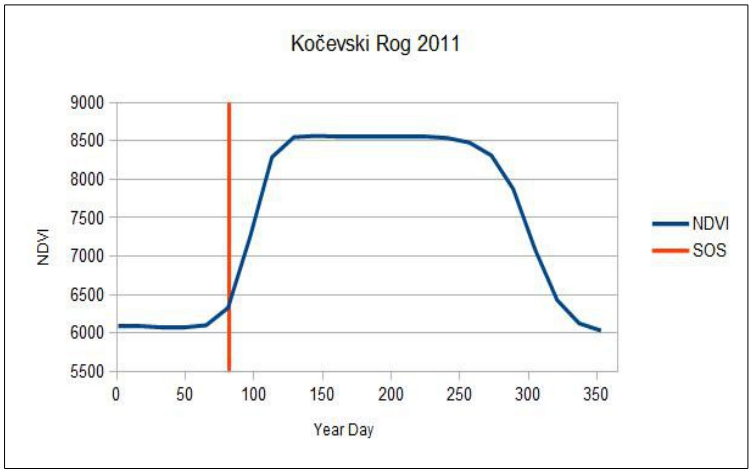

| 2010 | | | |
|---|---|---|---|
| Day | Adj KG | Adj Day | 5 Day Avg |
| 137 | 48.9 | -0.5 | -0.1 |
| 138 | 48.9 | 0 | -0.06 |
| 139 | 48.8 | -0.1 | -0.06 |
| 140 | 48.8 | 0 | 0.1 |
| 141 | 49.1 | 0.3 | 0.14 |
| 142 | 49.4 | 0.3 | 0.84 |
| 143 | 49.6 | 0.2 | 0.98 |
| 144 | 53 | 3.4 | 1.02 |
| 145 | 53.7 | 0.7 | 1.14 |
| 146 | 54.2 | 0.5 | 1.34 |
| 147 | 55.1 | 0.9 | 0.74 |
| 148 | 56.3 | 1.2 | 0.74 |
| 149 | 56.7 | 0.4 | 0.54 |
| 150 | 57.4 | 0.7 | 0.32 |
| 151 | 56.9 | -0.5 | 0.1 |
| 152 | 56.7 | -0.2 | -0.04 |
| 153 | 56.8 | 0.1 | -0.08 |
| 154 | 56.5 | -0.3 | -0.02 |
| 155 | 57 | 0.5 | 0.42 |
| 156 | 56.8 | -0.2 | 0.88 |
| 157 | 58.8 | 2 | 1.36 |
| 158 | 61.2 | 2.4 | 1.66 |
| 159 | 63.3 | 2.1 | 2.04 |
| 160 | 65.3 | 2 | 1.76 |
| 161 | 67 | 1.7 | 1.44 |
| 162 | 67.6 | 0.6 | 1.16 |
| 163 | 68.4 | 0.8 | 0.78 |
| 164 | 69.1 | 0.7 | 0.48 |
| 165 | 69.2 | 0.1 | 0.28 |
| 166 | 69.4 | 0.2 | -0.02 |
| 167 | 69 | -0.4 | -0.26 |
| 168 | 68.3 | -0.7 | -0.34 |
| 169 | 67.8 | -0.5 | -0.5 |
| 170 | 67.5 | -0.3 | -0.46 |
| 171 | 66.9 | -0.6 | -0.46 |
| 172 | 66.7 | -0.2 | -0.5 |
| 173 | 66 | -0.7 | -0.46 |
| 174 | 65.3 | -0.7 | -0.18 |
| 175 | 65.2 | -0.1 | -0.16 |
| 176 | 66 | 0.8 | 0.28 |
| 177 | 65.9 | -0.1 | 0.84 |
| 178 | 67.4 | 1.5 | 1.56 |
| 179 | 69.5 | 2.1 | 1.9 |
| 180 | 73 | 3.5 | 2.38 |
| 181 | 75.5 | 2.5 | 2.86 |
| 182 | 77.8 | 2.3 | 2.44 |
| 183 | 81.7 | 3.9 | 3.24 |
| 184 | 81.7 | 0 | 4.38 |
| 185 | 89.2 | 7.5 | 4.3 |
| 186 | 97.4 | 8.2 | 4.66 |
| 188 | 99.3 | 1.9 | 5.86 |
| 189 | 105 | 5.7 | 5.06 |
| 190 | 111 | 6 | 3.76 |
| 191 | 114.5 | 3.5 | 4.56 |
| 192 | 116.2 | 1.7 | 3.56 |
| 193 | 122.1 | 5.9 | 3.28 |
| 195 | 122.8 | 0.7 | 2.94 |
| 196 | 127.4 | 4.6 | 2.8 |
| 197 | 129.2 | 1.8 | 1.62 |
| 198 | 130.2 | 1 | 1.42 |
| 199 | 130.2 | 0 | 0.56 |
| 200 | 129.9 | -0.3 | 0.32 |

| Name | X | Y | Ele. (m) | DMEER |
|---|---|---|---|---|
| Kočevski Rog | 45.7086 | 15.0293 | 535 | Pannonian mixed forests |

| 2011 HBNF | Day | Weight (KG) |
|---|---|---|
| NF Start | 126 | 54.9 |
| NF End | 181 | 85.4 |
| NF Duration | 55 | 30.5 |
| Quarter | | 7.625 |
| 25% Flow | 133 | 62.525 |
| 50% Flow | 147 | 70.15 |
| 75% Flow | 169 | 77.775 |



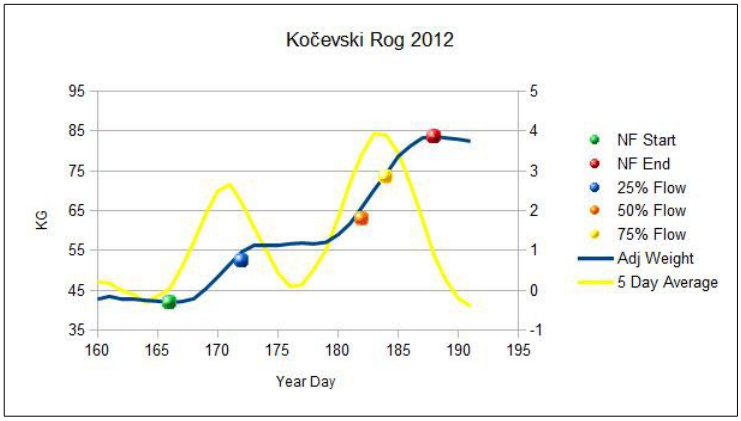

| 2011 NDVI | Year Day | | Value |
|---|---|---|---|
| SOS | 82.24 | Base val | 6042 |
| End | 322.08 | Peak val | 8567 |
| Length | 240 | Ampl. | 2525 |
| Peak t | 195.04 | L.deriv. | 982.2 |
| | | R.deriv. | 675.7 |
| | | L.integral | 134600 |
| | | S.integral | 31910 |



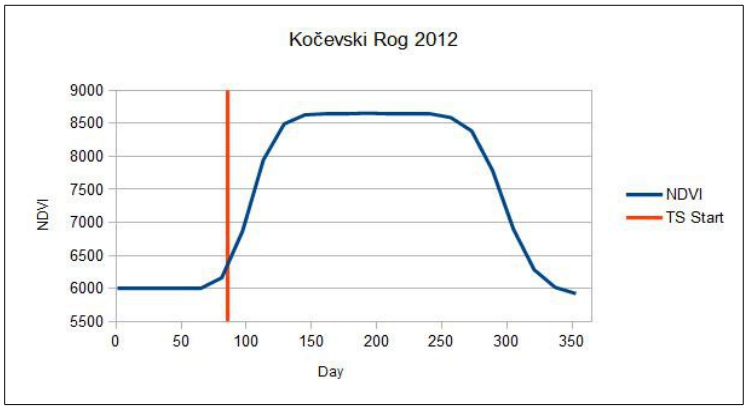

| 2011 | | | |
|---|---|---|---|
| Day | Adj KG | Adj Day | 5 Day Avg |
| 124 | 55.1 | -0.7 | -0.08 |
| 125 | 54.7 | -0.4 | 0.24 |
| 126 | 54.9 | 0.2 | 0.16 |
| 127 | 56.5 | 1.6 | 0.16 |
| 128 | 56.6 | 0.1 | 0.66 |
| 129 | 55.9 | -0.7 | 1.04 |
| 130 | 58 | 2.1 | 1.1 |
| 131 | 60.1 | 2.1 | 1.26 |
| 132 | 62 | 1.9 | 1.68 |
| 133 | 62.9 | 0.9 | 1.14 |
| 134 | 64.3 | 1.4 | 0.66 |
| 135 | 63.7 | -0.6 | 0.32 |
| 136 | 63.4 | -0.3 | 0.4 |
| 137 | 63.6 | 0.2 | 0.34 |
| 138 | 64.9 | 1.3 | 0.72 |
| 139 | 66 | 1.1 | 0.94 |
| 140 | 67.3 | 1.3 | 0.9 |
| 141 | 68.1 | 0.8 | 0.68 |
| 142 | 68.1 | 0 | 0.58 |
| 143 | 68.3 | 0.2 | 0.42 |
| 144 | 68.9 | 0.6 | 0.36 |
| 145 | 69.4 | 0.5 | 0.52 |
| 146 | 69.9 | 0.5 | 0.4 |
| 147 | 70.7 | 0.8 | 0.22 |
| 148 | 70.3 | -0.4 | 0.18 |
| 149 | 70 | -0.3 | 0.18 |
| 150 | 70.3 | 0.3 | 0.08 |
| 151 | 70.8 | 0.5 | 0.16 |
| 152 | 71.1 | 0.3 | 0.3 |
| 153 | 71.1 | 0 | 0.22 |
| 154 | 71.5 | 0.4 | 0.22 |
| 155 | 71.4 | -0.1 | 0.14 |
| 156 | 71.9 | 0.5 | 0.18 |
| 157 | 71.8 | -0.1 | 0.04 |
| 158 | 72 | 0.2 | 0.08 |
| 159 | 71.7 | -0.3 | -0.08 |
| 160 | 71.8 | 0.1 | -0.16 |
| 161 | 71.5 | -0.3 | -0.18 |
| 162 | 71 | -0.5 | -0.02 |
| 163 | 71.1 | 0.1 | 0.1 |
| 164 | 71.6 | 0.5 | 0.3 |
| 165 | 72.3 | 0.7 | 0.84 |
| 166 | 73 | 0.7 | 1.14 |
| 167 | 75.2 | 2.2 | 1.5 |
| 168 | 76.8 | 1.6 | 1.22 |
| 169 | 79.1 | 2.3 | 0.9 |
| 170 | 78.4 | -0.7 | 0.64 |
| 171 | 77.5 | -0.9 | 0.7 |
| 172 | 78.4 | 0.9 | 0.52 |
| 173 | 80.3 | 1.9 | 0.58 |
| 174 | 81.7 | 1.4 | 0.56 |
| 175 | 81.3 | -0.4 | 0.52 |
| 176 | 80.3 | -1 | 0.36 |
| 177 | 81 | 0.7 | 0.28 |
| 178 | 82.1 | 1.1 | 0.64 |
| 179 | 83.1 | 1 | 1.02 |
| 180 | 84.5 | 1.4 | 0.74 |
| 181 | 85.4 | 0.9 | 0.36 |
| 182 | 84.7 | -0.7 | 0.2 |

| Name | X | Y | Ele. (m) | DMEER |
|---|---|---|---|---|
| Kočevski Rog | 45.7086 | 15.0293 | 535 | Pannonian mixed forests |

| 2012 HBNF | Day | Weight (KG) |
|---|---|---|
| NF Start | 166 | 42 |
| NF End | 188 | 83.7 |
| NF Duration | 22 | 41.7 |
| Quarter | | 10.425 |
| 25% Flow | 172 | 52.425 |
| 50% Flow | 182 | 62.85 |
| 75% Flow | 184 | 73.275 |



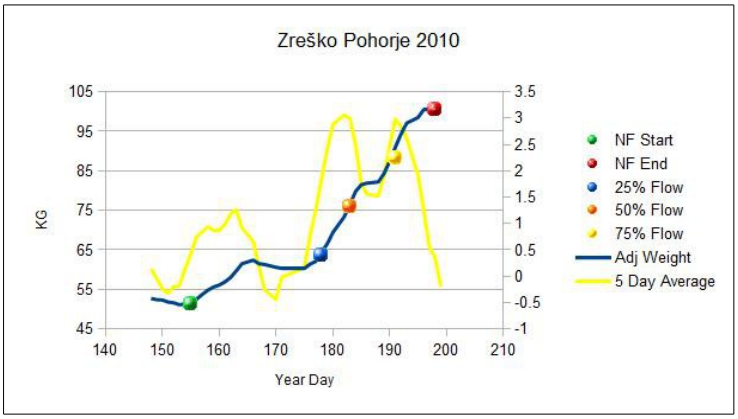

| 2012 NDVI | Day | | Value |
|---|---|---|---|
| SOS | 85.44 | Base val | 5942 |
| End | 319.68 | Peak val | 8654 |
| Length | 234.24 | Ampl. | 2712 |
| Peak t | 198.4 | L.deriv. | 883.9 |
| | | R.deriv. | 731.3 |
| | | L.integral | 127900 |
| | | S.integral | 32870 |



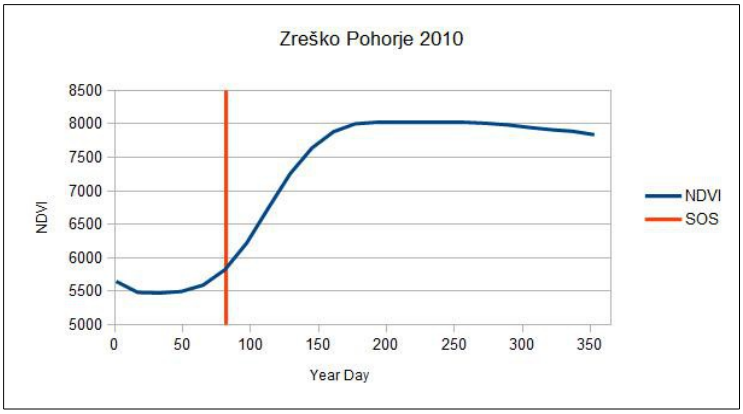

| 2012 | | | |
|---|---|---|---|
| Day | Adj KG | Adj Day | 5 Day Avg |
| 150 | 41.6 | 0 | 0.08 |
| 151 | 41.7 | 0.1 | 0.06 |
| 152 | 42 | 0.3 | 0 |
| 153 | 41.9 | -0.1 | 0.04 |
| 154 | 41.6 | -0.3 | 0.04 |
| 155 | 41.8 | 0.2 | -0.04 |
| 156 | 41.9 | 0.1 | -0.02 |
| 157 | 41.8 | -0.1 | 0.18 |
| 158 | 41.8 | 0 | 0.2 |
| 159 | 42.5 | 0.7 | 0.32 |
| 160 | 42.8 | 0.3 | 0.22 |
| 161 | 43.5 | 0.7 | 0.18 |
| 162 | 42.9 | -0.6 | 0 |
| 163 | 42.7 | -0.2 | -0.1 |
| 164 | 42.5 | -0.2 | -0.3 |
| 165 | 42.3 | -0.2 | -0.14 |
| 166 | 42 | -0.3 | 0.04 |
| 167 | 42.2 | 0.2 | 0.58 |
| 168 | 42.9 | 0.7 | 1.22 |
| 169 | 45.4 | 2.5 | 1.92 |
| 170 | 48.4 | 3 | 2.5 |
| 171 | 51.6 | 3.2 | 2.66 |
| 172 | 54.7 | 3.1 | 2.2 |
| 173 | 56.2 | 1.5 | 1.58 |
| 174 | 56.4 | 0.2 | 1.02 |
| 175 | 56.3 | -0.1 | 0.44 |
| 176 | 56.7 | 0.4 | 0.1 |
| 177 | 56.9 | 0.2 | 0.14 |
| 178 | 56.7 | -0.2 | 0.54 |
| 179 | 57.1 | 0.4 | 1.02 |
| 180 | 59 | 1.9 | 1.82 |
| 181 | 61.8 | 2.8 | 2.72 |
| 182 | 66 | 4.2 | 3.44 |
| 183 | 70.3 | 4.3 | 3.94 |
| 184 | 74.3 | 4 | 3.9 |
| 185 | 78.7 | 4.4 | 3.46 |
| 186 | 81.3 | 2.6 | 2.68 |
| 187 | 83.3 | 2 | 1.8 |
| 188 | 83.7 | 0.4 | 0.86 |
| 189 | 83.3 | -0.4 | 0.24 |
| 190 | 83 | -0.3 | -0.2 |
| 191 | 82.5 | -0.5 | -0.4 |

| Name | X | Y | Ele. (m) | DMEER |
|---|---|---|---|---|
| Zreško Pohorje | 46.440 | 15.351 | 1143 | Alps conifer and mixed forests |

| **2010 HBNF** | Day | Weight (KG) |
|---|---|---|
| NF Start | 155 | 51.4 |
| NF End | 198 | 100.6 |
| NF Duration | 43 | 49.2 |
| Quarter | | 12.3 |
| 25% Flow | 178 | 63.7 |
| 50% Flow | 183 | 76 |
| 75% Flow | 191 | 88.3 |



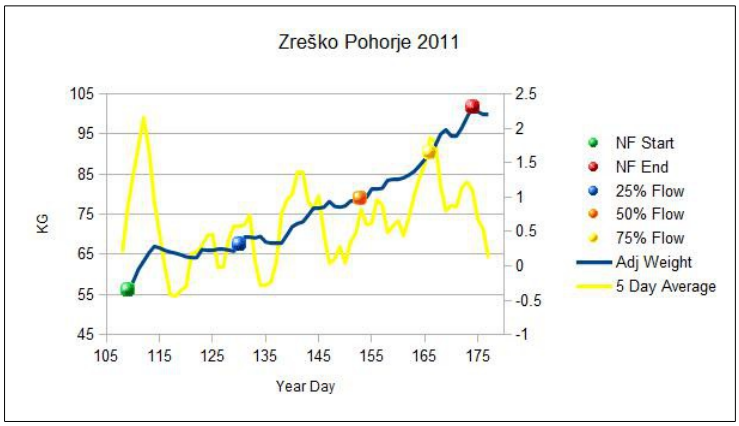

| **2010 NDVI** | Year Day | | Value |
|---|---|---|---|
| SOS | 81.44 | Base val | 5722 |
| End | 405.28 | Peak val | 8033 |
| Length | 324 | Ampl. | 2310 |
| Peak t | 254.08 | L.deriv. | 468.3 |
| | | R.deriv. | 603.3 |
| | | L.integral | 164500 |
| | | S.integral | 38630 |



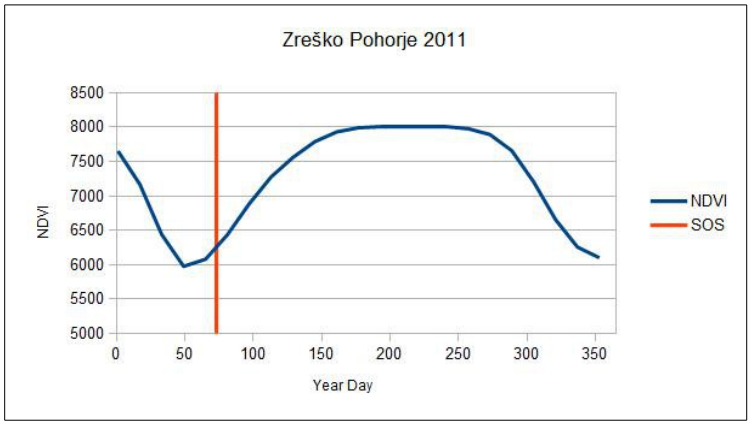

| Day | Adj KG | Adj Day | 5 Day Avg |
|---|---|---|---|
| 148 | 52.7 | -0.1 | 0.14 |
| 149 | 52.4 | -0.3 | -0.04 |
| 150 | 52.3 | -0.1 | -0.24 |
| 151 | 51.8 | -0.5 | -0.32 |
| 152 | 51.6 | -0.2 | -0.2 |
| 153 | 51.1 | -0.5 | -0.18 |
| 154 | 51.4 | 0.3 | 0.14 |
| 155 | 51.4 | 0 | 0.42 |
| 156 | 52.5 | 1.1 | 0.74 |
| 157 | 53.7 | 1.2 | 0.84 |
| 158 | 54.8 | 1.1 | 0.94 |
| 159 | 55.6 | 0.8 | 0.88 |
| 160 | 56.1 | 0.5 | 0.86 |
| 161 | 56.9 | 0.8 | 0.98 |
| 162 | 58 | 1.1 | 1.18 |
| 163 | 59.7 | 1.7 | 1.26 |
| 164 | 61.5 | 1.8 | 0.92 |
| 166 | 62.4 | 0.9 | 0.66 |
| 167 | 61.5 | -0.9 | 0.18 |
| 168 | 61.3 | -0.2 | -0.26 |
| 170 | 60.6 | -0.7 | -0.44 |
| 171 | 60.2 | -0.4 | -0.02 |
| 175 | 60.2 | 0 | 0.16 |
| 176 | 61.4 | 1.2 | 0.78 |
| 177 | 62.1 | 0.7 | 1.26 |
| 178 | 64.5 | 2.4 | 1.84 |
| 179 | 66.5 | 2 | 2.4 |
| 180 | 69.4 | 2.9 | 2.88 |
| 182 | 73.4 | 4 | 3.06 |
| 183 | 76.5 | 3.1 | 3 |
| 184 | 79.8 | 3.3 | 2.5 |
| 185 | 81.5 | 1.7 | 1.76 |
| 186 | 81.9 | 0.4 | 1.56 |
| 188 | 82.2 | 0.3 | 1.52 |
| 189 | 84.3 | 2.1 | 1.9 |
| 190 | 87.4 | 3.1 | 2.48 |
| 191 | 91 | 3.6 | 2.98 |
| 192 | 94.3 | 3.3 | 2.84 |
| 193 | 97.1 | 2.8 | 2.62 |
| 195 | 98.5 | 1.4 | 1.92 |
| 196 | 100.5 | 2 | 1.26 |
| 197 | 100.6 | 0.1 | 0.56 |
| 198 | 100.6 | 0 | 0.35 |
| 199 | 99.9 | -0.7 | -0.2 |

| Name | X | Y | Ele. (m) | DMEER |
|---|---|---|---|---|
| Zreško Pohorje | 46.440 | 15.351 | 1143 | Alps conifer and mixed forests |

| 2011 HBNF | Year Day | Weight (KG) |
|---|---|---|
| NF Start | 109 | 56.2 |
| NF End | 174 | 101.8 |
| NF Duration | 65 | 45.6 |
| Quarter | | 11.4 |
| 25% Flow | 130 | 67.6 |
| 50% Flow | 153 | 79 |
| 75% Flow | 166 | 90.4 |



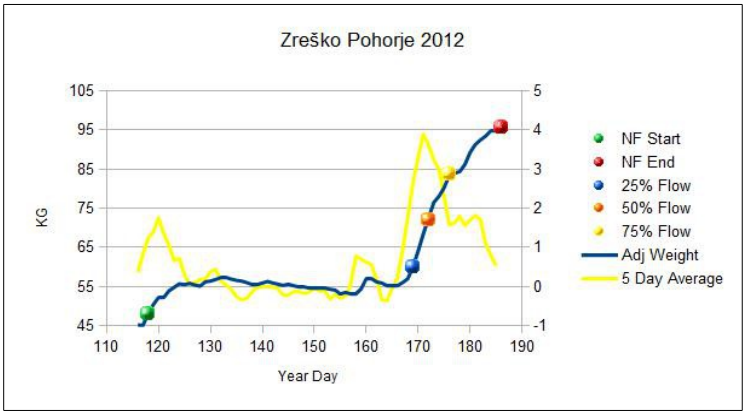

| 2011 NDVI | Year Day | | Value |
|---|---|---|---|
| SOS | 72.96 | Base val | 6031 |
| End | 331.04 | Peak val | 8002 |
| Length | 258.08 | Ampl. | 1971 |
| Peak t | 209.92 | L.deriv. | 367.1 |
| | | R.deriv. | 483.4 |
| | | L.integral | 133600 |
| | | S.integral | 25010 |



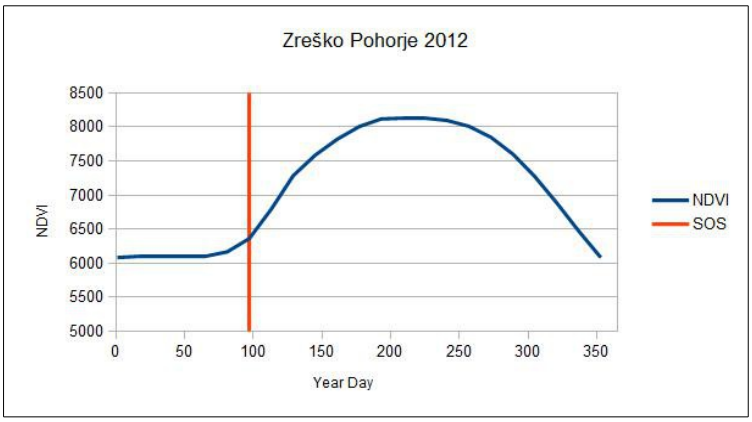

| 2011 | | | |
|---|---|---|---|
| Day | Adj KG | Adj Day | 5 Day Avg |
| 108 | 56.7 | 0 | 0.2 |
| 109 | 56.2 | -0.5 | 0.86 |
| 110 | 58.2 | 2 | 1.32 |
| 111 | 61.3 | 3.1 | 1.74 |
| 112 | 63.3 | 2 | 2.16 |
| 113 | 65.4 | 2.1 | 1.68 |
| 114 | 67 | 1.6 | 0.94 |
| 115 | 66.6 | -0.4 | 0.46 |
| 116 | 66 | -0.6 | -0.02 |
| 117 | 65.6 | -0.4 | -0.42 |
| 118 | 65.3 | -0.3 | -0.44 |
| 119 | 64.9 | -0.4 | -0.36 |
| 120 | 64.4 | -0.5 | -0.3 |
| 121 | 64.2 | -0.2 | 0.18 |
| 122 | 64.1 | -0.1 | 0.2 |
| 123 | 66.2 | 2.1 | 0.3 |
| 124 | 65.9 | -0.3 | 0.44 |
| 125 | 65.9 | 0 | 0.46 |
| 126 | 66.4 | 0.5 | -0.02 |
| 127 | 66.4 | 0 | -0.02 |
| 128 | 66.1 | -0.3 | 0.38 |
| 129 | 65.8 | -0.3 | 0.58 |
| 130 | 67.8 | 2 | 0.58 |
| 131 | 69.3 | 1.5 | 0.6 |
| 132 | 69.3 | 0 | 0.74 |
| 133 | 69.1 | -0.2 | 0.06 |
| 134 | 69.5 | 0.4 | -0.28 |
| 135 | 68.1 | -1.4 | -0.28 |
| 136 | 67.9 | -0.2 | -0.24 |
| 137 | 67.9 | 0 | 0.06 |
| 138 | 67.9 | 0 | 0.76 |
| 139 | 69.8 | 1.9 | 0.96 |
| 140 | 71.9 | 2.1 | 1.04 |
| 141 | 72.7 | 0.8 | 1.36 |
| 142 | 73.1 | 0.4 | 1.36 |
| 143 | 74.7 | 1.6 | 0.94 |
| 144 | 76.6 | 1.9 | 0.82 |
| 145 | 76.6 | 0 | 1.02 |
| 146 | 76.8 | 0.2 | 0.46 |
| 147 | 78.2 | 1.4 | 0.04 |
| 148 | 77 | -1.2 | 0.1 |
| 149 | 76.8 | -0.2 | 0.28 |
| 150 | 77.1 | 0.3 | 0.04 |
| 151 | 78.2 | 1.1 | 0.34 |
| 152 | 78.4 | 0.2 | 0.48 |
| 153 | 78.7 | 0.3 | 0.82 |
| 154 | 79.2 | 0.5 | 0.6 |
| 155 | 81.2 | 2 | 0.62 |
| 156 | 81.2 | 0 | 0.96 |
| 157 | 81.5 | 0.3 | 0.88 |
| 158 | 83.5 | 2 | 0.48 |
| 159 | 83.6 | 0.1 | 0.58 |
| 160 | 83.6 | 0 | 0.66 |
| 161 | 84.1 | 0.5 | 0.44 |
| 162 | 84.8 | 0.7 | 0.7 |
| 163 | 85.7 | 0.9 | 1.02 |
| 164 | 87.1 | 1.4 | 1.28 |
| 165 | 88.7 | 1.6 | 1.48 |
| 166 | 90.5 | 1.8 | 1.86 |
| 167 | 92.2 | 1.7 | 1.8 |
| 168 | 95 | 2.8 | 1.16 |
| 169 | 96.1 | 1.1 | 0.8 |
| 170 | 94.5 | -1.6 | 0.88 |
| 171 | 94.5 | 0 | 0.86 |
| 172 | 96.6 | 2.1 | 1.14 |
| 173 | 99.3 | 2.7 | 1.22 |
| 174 | 101.8 | 2.5 | 1.1 |
| 175 | 100.6 | -1.2 | 0.68 |

| Name | X | Y | Ele. (m) | DMEER |
|---|---|---|---|---|
| Zreško Pohorje | 46.440 | 15.351 | 1143 | Alps conifer and mixed forests |

| **2012 HBNF** | Day | Weight (KG) |
|---|---|---|
| NF Start | 118 | 48 |
| NF End | 186 | 95.8 |
| NF Duration | 68 | 47.8 |
| Quarter | | 11.95 |
| 25% Flow | 169 | 59.95 |
| 50% Flow | 172 | 71.9 |
| 75% Flow | 176 | 83.85 |



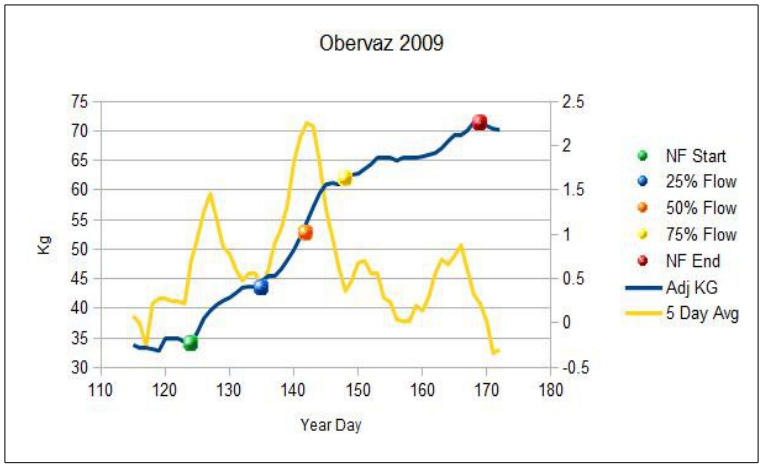

| **2012 NDVI** | Year Day | | Value |
|---|---|---|---|
| SOS | 97.28 | Base val | 5784 |
| End | 363.36 | Peak val | 8136 |
| Length | 265.92 | Ampl. | 2353 |
| Peak t | 220.64 | L.deriv. | 373.6 |
| | | R.deriv. | 372.2 |
| | | L.integral | 132300 |
| | | S.integral | 28170 |



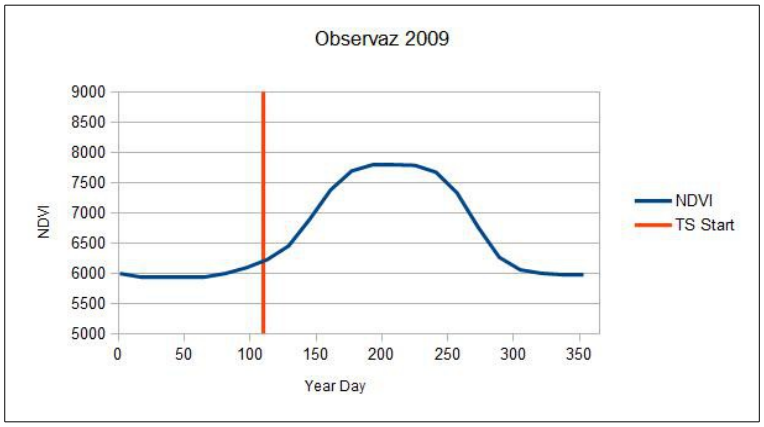

| **2012** | | | |
|---|---|---|---|
| Day | Adj KG | Adj Day | 5 Day Avg |
| 117 | 45.1 | -0.1 | 0.84 |
| 118 | 48 | 2.9 | 1.24 |
| 119 | 50.4 | 2.4 | 1.4 |
| 120 | 52.2 | 1.8 | 1.76 |
| 121 | 52.2 | 0 | 1.36 |
| 122 | 53.9 | 1.7 | 1.06 |
| 123 | 54.8 | 0.9 | 0.66 |
| 124 | 55.7 | 0.9 | 0.72 |
| 125 | 55.5 | -0.2 | 0.3 |
| 126 | 55.8 | 0.3 | 0.06 |
| 127 | 55.4 | -0.4 | 0.1 |
| 128 | 55.1 | -0.3 | 0.18 |
| 129 | 56.2 | 1.1 | 0.2 |
| 130 | 56.4 | 0.2 | 0.38 |
| 131 | 56.8 | 0.4 | 0.44 |
| 132 | 57.3 | 0.5 | 0.14 |
| 133 | 57.3 | 0 | 0.04 |
| 134 | 56.9 | -0.4 | -0.08 |
| 135 | 56.6 | -0.3 | -0.26 |
| 136 | 56.4 | -0.2 | -0.34 |
| 137 | 56 | -0.4 | -0.3 |
| 138 | 55.6 | -0.4 | -0.14 |
| 139 | 55.4 | -0.2 | -0.02 |
| 140 | 55.9 | 0.5 | -0.02 |
| 141 | 56.3 | 0.4 | 0 |
| 142 | 55.9 | -0.4 | -0.02 |
| 143 | 55.6 | -0.3 | -0.06 |
| 144 | 55.3 | -0.3 | -0.22 |
| 145 | 55.6 | 0.3 | -0.22 |
| 146 | 55.2 | -0.4 | -0.14 |
| 147 | 54.8 | -0.4 | -0.14 |
| 148 | 54.9 | 0.1 | -0.18 |
| 149 | 54.6 | -0.3 | -0.14 |
| 150 | 54.7 | 0.1 | -0.04 |
| 151 | 54.5 | -0.2 | -0.12 |
| 152 | 54.6 | 0.1 | -0.1 |
| 153 | 54.3 | -0.3 | -0.32 |
| 154 | 54.1 | -0.2 | -0.2 |
| 155 | 53.1 | -1 | -0.3 |
| 156 | 53.5 | 0.4 | -0.24 |
| 157 | 53.1 | -0.4 | 0.06 |
| 158 | 53.1 | 0 | 0.78 |
| 159 | 54.4 | 1.3 | 0.7 |
| 160 | 57 | 2.6 | 0.62 |
| 161 | 57 | 0 | 0.56 |
| 162 | 56.2 | -0.8 | 0.18 |
| 163 | 55.9 | -0.3 | -0.34 |
| 164 | 55.3 | -0.6 | -0.36 |
| 165 | 55.3 | 0 | -0.04 |
| 166 | 55.2 | -0.1 | 0.22 |
| 167 | 56 | 0.8 | 0.94 |
| 168 | 57 | 1 | 1.76 |
| 169 | 60 | 3 | 2.66 |
| 170 | 64.1 | 4.1 | 3.3 |
| 171 | 68.5 | 4.4 | 3.9 |
| 172 | 72.5 | 4 | 3.62 |
| 173 | 76.5 | 4 | 3.24 |
| 174 | 78.1 | 1.6 | 3 |
| 175 | 80.3 | 2.2 | 2.3 |
| 176 | 83.5 | 3.2 | 1.58 |
| 177 | 84 | 0.5 | 1.62 |
| 178 | 84.4 | 0.4 | 1.8 |
| 179 | 86.2 | 1.8 | 1.56 |
| 180 | 89.3 | 3.1 | 1.7 |
| 181 | 91.3 | 2 | 1.82 |
| 182 | 92.5 | 1.2 | 1.7 |
| 183 | 93.5 | 1 | 1.08 |
| 184 | 94.7 | 1.2 | 0.8 |
| 185 | 94.7 | 0 | 0.54 |
| 186 | 95.3 | 0.6 | 0.28 |

| Name | X | Y | Ele. (m) | DMEER |
|---|---|---|---|---|
| Vaz/Obervaz | 46.7151 | 9.5376 | 1162 | Alps conifer and mixed forests |

| 2009 HBNF | Day | Weight (KG) |
|---|---|---|
| NF Start | 124 | 34 |
| NF End | 169 | 71.3 |
| NF Duration | 45 | 37.3 |
| Quarter | | 9.325 |
| 25% Flow | 132 | 43.325 |
| 50% Flow | 142 | 52.65 |
| 75% Flow | 148 | 61.975 |



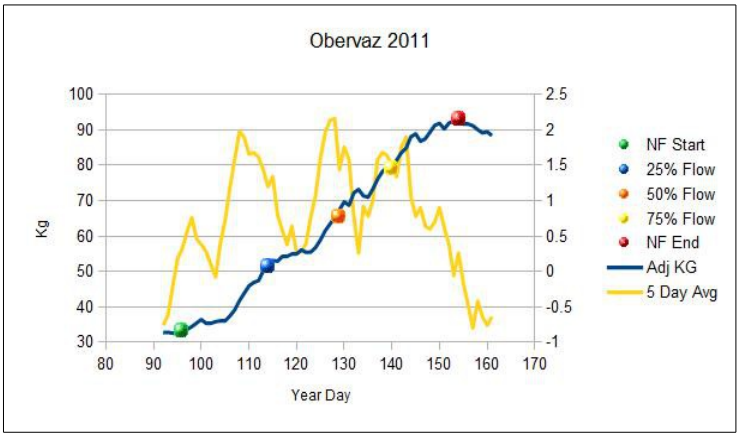

| 2009 NDVI | Year Day | | Value |
|---|---|---|---|
| TS Start 15% | 110.032 | Base val | 5947 |
| End 15% | 289.12 | Peak val | 7797 |
| Length | 11.2 | Ampl. | 1850 |
| Peak t | 206.72 | L.deriv. | 400.1 |
| | | R.deriv. | 507.4 |
| | | L.integral | 98130 |
| | | S.integral | 14870 |



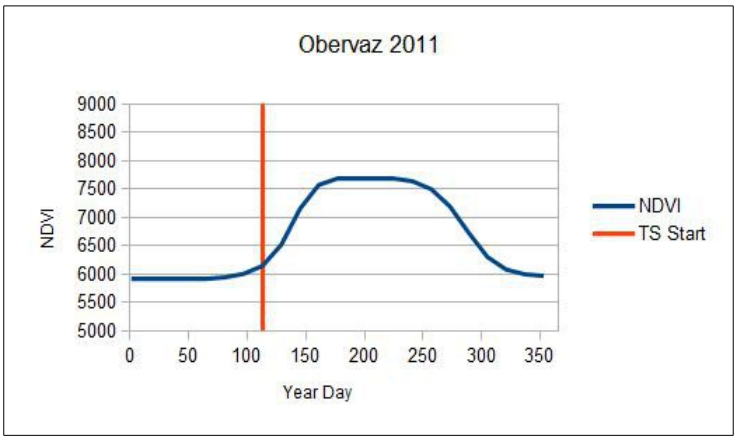

| 2009 | | | |
|---|---|---|---|
| Day | Adj KG | Adj Day | 5 Day Avg |
| 109 | 33.1 | 0 | -0.08 |
| 110 | 33.1 | 0 | -0.04 |
| 111 | 33.1 | 0 | 0 |
| 112 | 33 | -0.1 | 0.2 |
| 113 | 33.1 | 0.1 | 0.14 |
| 114 | 34.1 | 1 | 0.06 |
| 115 | 33.8 | -0.3 | 0.08 |
| 116 | 33.4 | -0.4 | 0 |
| 117 | 33.4 | 0 | -0.26 |
| 118 | 33.1 | -0.3 | 0.22 |
| 119 | 32.8 | -0.3 | 0.28 |
| 120 | 34.9 | 2.1 | 0.28 |
| 121 | 34.8 | -0.1 | 0.24 |
| 122 | 34.8 | 0 | 0.24 |
| 123 | 34.3 | -0.5 | 0.22 |
| 124 | 34 | -0.3 | 0.7 |
| 125 | 36 | 2 | 0.96 |
| 126 | 38.3 | 2.3 | 1.26 |
| 127 | 39.6 | 1.3 | 1.46 |
| 128 | 40.6 | 1 | 1.16 |
| 129 | 41.3 | 0.7 | 0.86 |
| 130 | 41.8 | 0.5 | 0.78 |
| 131 | 42.6 | 0.8 | 0.6 |
| 132 | 43.5 | 0.9 | 0.48 |
| 133 | 43.6 | 0.1 | 0.56 |
| 134 | 43.7 | 0.1 | 0.56 |
| 135 | 44.6 | 0.9 | 0.4 |
| 136 | 45.4 | 0.8 | 0.6 |
| 137 | 45.5 | 0.1 | 0.9 |
| 138 | 46.6 | 1.1 | 1.06 |
| 139 | 48.2 | 1.6 | 1.34 |
| 140 | 49.9 | 1.7 | 1.82 |
| 141 | 52.1 | 2.2 | 2.1 |
| 142 | 54.6 | 2.5 | 2.26 |
| 143 | 57.1 | 2.5 | 2.22 |
| 144 | 59.5 | 2.4 | 1.82 |
| 145 | 61 | 1.5 | 1.28 |
| 146 | 61.2 | 0.2 | 0.96 |
| 147 | 61 | -0.2 | 0.62 |
| 148 | 61.9 | 0.9 | 0.36 |
| 149 | 62.6 | 0.7 | 0.48 |
| 150 | 62.8 | 0.2 | 0.68 |
| 151 | 63.6 | 0.8 | 0.7 |
| 152 | 64.4 | 0.8 | 0.56 |
| 153 | 65.4 | 1 | 0.56 |
| 154 | 65.4 | 0 | 0.28 |
| 155 | 65.6 | 0.2 | 0.24 |
| 156 | 65 | -0.6 | 0.04 |
| 157 | 65.6 | 0.6 | 0.02 |
| 158 | 65.6 | 0 | 0.02 |
| 159 | 65.5 | -0.1 | 0.2 |
| 160 | 65.7 | 0.2 | 0.14 |
| 161 | 66 | 0.3 | 0.3 |
| 162 | 66.3 | 0.3 | 0.56 |
| 163 | 67.1 | 0.8 | 0.72 |
| 164 | 68.3 | 1.2 | 0.66 |
| 165 | 69.3 | 1 | 0.76 |
| 166 | 69.3 | 0 | 0.88 |
| 167 | 70.1 | 0.8 | 0.6 |
| 168 | 71.5 | 1.4 | 0.32 |
| 169 | 71.3 | -0.2 | 0.22 |
| 170 | 70.9 | -0.4 | 0.02 |
| 171 | 70.4 | -0.5 | -0.34 |
| 172 | 70.2 | -0.2 | -0.3 |

| Name | X | Y | Ele. (m) | DMEER |
|---|---|---|---|---|
| Vaz/Obervaz | 46.715 | 9.538 | 1162 | Alps conifer and mixed forests |

| 2011 HBNF | Day | Weight (KG) |
|---|---|---|
| NF Start | 96 | 33.1 |
| NF End | 154 | 93.2 |
| NF Duration | 48 | 55.8 |
| Quarter | | 13.95 |
| 25% Flow | 114 | 51.35 |
| 50% Flow | 129 | 65.3 |
| 75% Flow | 140 | 79.25 |



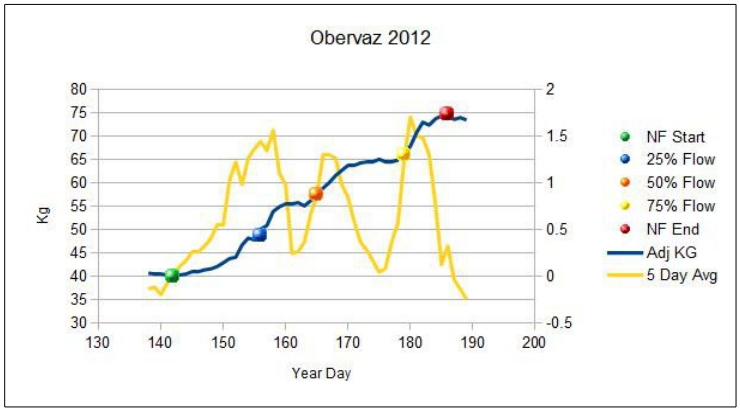

| 2011 NDVI | Year Day | | Value |
|---|---|---|---|
| SOS | 113.6 | Base val | 5934 |
| End | 309.92 | Peak val | 7690 |
| Length | 196.32 | Ampl. | 1756 |
| Peak t | 207.52 | L.deriv. | 508 |
| | | R.deriv. | 417.8 |
| | | L.integral | 99550 |
| | | S.integral | 16470 |



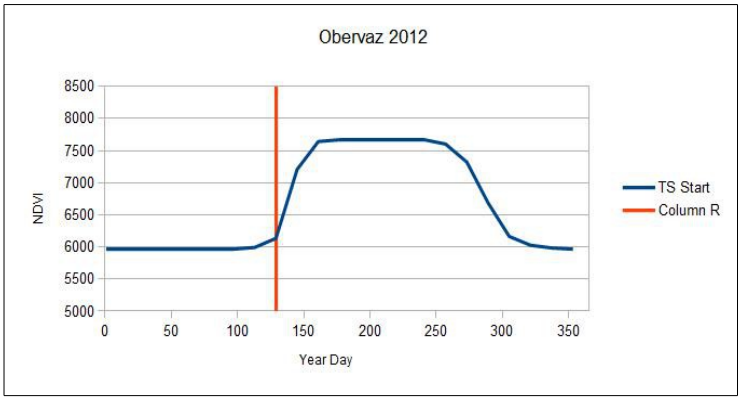

| 2011 | | | |
|---|---|---|---|
| Day | Adj KG | Adj Day | 5 Day Avg |
| 90 | 35.7 | -0.7 | -0.82 |
| 91 | 34.2 | -1.5 | -0.78 |
| 92 | 32.7 | -1.5 | -0.76 |
| 93 | 32.8 | 0.1 | -0.62 |
| 94 | 32.6 | -0.2 | -0.22 |
| 95 | 32.6 | 0 | 0.18 |
| 96 | 33.1 | 0.5 | 0.32 |
| 97 | 33.6 | 0.5 | 0.56 |
| 98 | 34.4 | 0.8 | 0.76 |
| 99 | 35.4 | 1 | 0.46 |
| 100 | 36.4 | 1 | 0.38 |
| 101 | 35.4 | -1 | 0.28 |
| 102 | 35.5 | 0.1 | 0.1 |
| 103 | 35.8 | 0.3 | -0.08 |
| 104 | 35.9 | 0.1 | 0.4 |
| 105 | 36 | 0.1 | 0.72 |
| 106 | 37.4 | 1.4 | 1.18 |
| 107 | 39.1 | 1.7 | 1.58 |
| 108 | 41.7 | 2.6 | 1.98 |
| 109 | 43.8 | 2.1 | 1.9 |
| 110 | 45.9 | 2.1 | 1.66 |
| 111 | 46.9 | 1 | 1.68 |
| 112 | 47.4 | 0.5 | 1.62 |
| 113 | 50.1 | 2.7 | 1.44 |
| 114 | 51.9 | 1.8 | 1.2 |
| 115 | 53.1 | 1.2 | 1.34 |
| 116 | 52.9 | -0.2 | 0.8 |
| 117 | 54.1 | 1.2 | 0.58 |
| 118 | 54.1 | 0 | 0.38 |
| 119 | 54.8 | 0.7 | 0.64 |
| 120 | 55 | 0.2 | 0.26 |
| 121 | 56.1 | 1.1 | 0.28 |
| 122 | 55.4 | -0.7 | 0.4 |
| 123 | 55.5 | 0.1 | 0.78 |
| 124 | 56.8 | 1.3 | 1.08 |
| 125 | 58.9 | 2.1 | 1.6 |
| 126 | 61.5 | 2.6 | 1.96 |
| 127 | 63.4 | 1.9 | 2.14 |
| 128 | 65.3 | 1.9 | 2.16 |
| 129 | 67.5 | 2.2 | 1.44 |
| 130 | 69.7 | 2.2 | 1.76 |
| 131 | 68.7 | -1 | 1.58 |
| 132 | 72.2 | 3.5 | 0.78 |
| 133 | 73.2 | 1 | 0.26 |
| 134 | 71.4 | -1.8 | 0.92 |
| 135 | 71 | -0.4 | 0.78 |
| 136 | 73.3 | 2.3 | 1 |
| 137 | 76.1 | 2.8 | 1.58 |
| 138 | 78.2 | 2.1 | 1.68 |
| 139 | 79.3 | 1.1 | 1.64 |
| 140 | 79.4 | 0.1 | 1.5 |
| 141 | 81.5 | 2.1 | 1.34 |
| 142 | 83.6 | 2.1 | 1.76 |
| 143 | 84.9 | 1.3 | 1.9 |
| 144 | 88.1 | 3.2 | 1.06 |
| 145 | 88.9 | 0.8 | 0.78 |
| 146 | 86.8 | -2.1 | 0.9 |
| 147 | 87.5 | 0.7 | 0.64 |
| 148 | 89.4 | 1.9 | 0.6 |
| 149 | 91.3 | 1.9 | 0.7 |
| 150 | 91.9 | 0.6 | 0.9 |
| 151 | 90.3 | -1.6 | 0.62 |
| 152 | 92 | 1.7 | 0.38 |
| 153 | 92.5 | 0.5 | -0.06 |
| 154 | 93.2 | 0.7 | 0.26 |
| 155 | 91.6 | -1.6 | -0.16 |
| 156 | 91.6 | 0 | -0.48 |
| 157 | 91.2 | -0.4 | -0.8 |

| Name | X | Y | Ele. (m) | DMEER |
|---|---|---|---|---|
| Vaz/Obervaz | 46.715 | 9.538 | 1162 | Alps conifer and mixed forests |

| 2012 HBNF | Day | Weight (KG) |
|---|---|---|
| NF Start | 142 | 40 |
| NF End | 186 | 74.6 |
| NF Duration | 44 | 34.6 |
| Quarter | | 8.65 |
| 25% Flow | 156 | 48.65 |
| 50% Flow | 165 | 57.3 |
| 75% Flow | 179 | 65.95 |



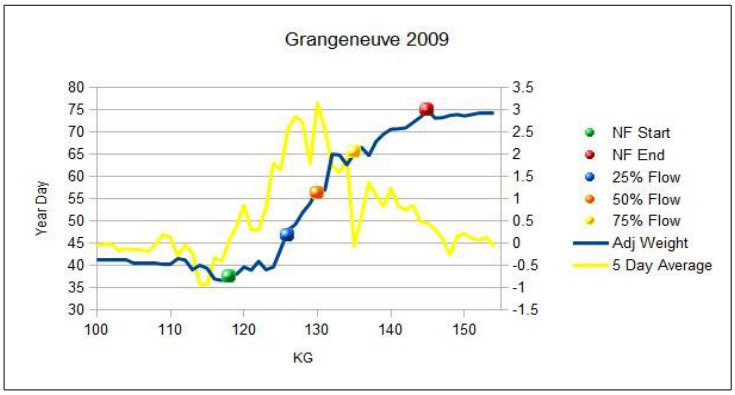

| 2012 NDVI | Year Day | | Value |
|---|---|---|---|
| TS Start 15% | 129.12 | Base val | 5934 |
| End 15% | 302.24 | Peak val | 7690 |
| Length | 172.96 | Ampl. | 1756 |
| Peak t | 225.92 | L.deriv. | 508 |
| | | R.deriv. | 417.8 |
| | | L.integral | 99550 |
| | | S.integral | 16470 |



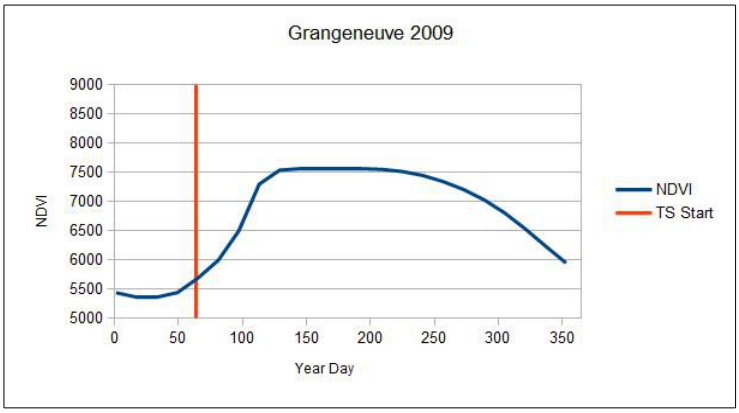

| 2012 | | | |
|---|---|---|---|
| Day | Adj KG | Adj Day | 5 Day Avg |
| 124 | 41.4 | 0 | 0.02 |
| 125 | 41.5 | 0.1 | 0 |
| 126 | 41.4 | -0.1 | -0.04 |
| 127 | 41.3 | -0.1 | 0 |
| 128 | 41.2 | -0.1 | 0 |
| 129 | 41.4 | 0.2 | 0.04 |
| 130 | 41.5 | 0.1 | 0 |
| 131 | 41.6 | 0.1 | 0 |
| 132 | 41.3 | -0.3 | -0.06 |
| 133 | 41.2 | -0.1 | -0.1 |
| 134 | 41.1 | -0.1 | -0.16 |
| 135 | 41 | -0.1 | -0.06 |
| 136 | 40.8 | -0.2 | -0.12 |
| 137 | 41 | 0.2 | -0.14 |
| 138 | 40.6 | -0.4 | -0.14 |
| 139 | 40.4 | -0.2 | -0.12 |
| 140 | 40.3 | -0.1 | -0.2 |
| 141 | 40.2 | -0.1 | -0.08 |
| 142 | 40 | -0.2 | 0 |
| 143 | 40.2 | 0.2 | 0.1 |
| 144 | 40.4 | 0.2 | 0.16 |
| 145 | 40.8 | 0.4 | 0.26 |
| 146 | 41 | 0.2 | 0.26 |
| 147 | 41.3 | 0.3 | 0.32 |
| 148 | 41.5 | 0.2 | 0.4 |
| 149 | 42 | 0.5 | 0.54 |
| 150 | 42.8 | 0.8 | 0.54 |
| 151 | 43.7 | 0.9 | 1.02 |
| 152 | 44 | 0.3 | 1.22 |
| 153 | 46.6 | 2.6 | 0.98 |
| 154 | 48.1 | 1.5 | 1.26 |
| 155 | 47.7 | -0.4 | 1.36 |
| 156 | 50 | 2.3 | 1.44 |
| 157 | 50.8 | 0.8 | 1.34 |
| 158 | 53.8 | 3 | 1.56 |
| 159 | 54.8 | 1 | 1.1 |
| 160 | 55.5 | 0.7 | 0.98 |
| 161 | 55.5 | 0 | 0.24 |
| 162 | 55.7 | 0.2 | 0.26 |
| 163 | 55 | -0.7 | 0.36 |
| 164 | 56.1 | 1.1 | 0.66 |
| 165 | 57.3 | 1.2 | 0.86 |
| 166 | 58.8 | 1.5 | 1.3 |
| 167 | 60 | 1.2 | 1.3 |
| 168 | 61.5 | 1.5 | 1.26 |
| 169 | 62.6 | 1.1 | 0.98 |
| 170 | 63.6 | 1 | 0.84 |
| 171 | 63.7 | 0.1 | 0.58 |
| 172 | 64.2 | 0.5 | 0.36 |
| 173 | 64.4 | 0.2 | 0.28 |
| 174 | 64.4 | 0 | 0.16 |
| 175 | 65 | 0.6 | 0.04 |
| 176 | 64.5 | -0.5 | 0.08 |
| 177 | 64.4 | -0.1 | 0.36 |
| 178 | 64.8 | 0.4 | 0.56 |
| 179 | 66.2 | 1.4 | 1.24 |
| 180 | 67.8 | 1.6 | 1.7 |
| 181 | 70.7 | 2.9 | 1.5 |
| 182 | 72.9 | 2.2 | 1.48 |
| 183 | 72.3 | -0.6 | 1.3 |
| 184 | 73.6 | 1.3 | 0.78 |
| 185 | 74.3 | 0.7 | 0.12 |
| 186 | 74.6 | 0.3 | 0.32 |
| 187 | 73.5 | -1.1 | -0.04 |
| 188 | 73.9 | 0.4 | -0.14 |
| 189 | 73.4 | -0.5 | -0.25 |
| 190 | 73.6 | 0.2 | 0.0333333333 |

| Name | X | Y | Ele. (m) | DMEER |
|---|---|---|---|---|
| Posieux (Grangeneuve) | 46.7643 | 7.0977 | 670 | Western European Broadleaf forests |

| 2009 HBNF | Day | Weight (KG) |
|---|---|---|
| NF Start | 118 | 37.5 |
| NF End | 145 | 75 |
| NF Duration | 27 | 37.5 |
| Quarter | | 9.375 |
| 25% Flow | 126 | 46.875 |
| 50% Flow | 130 | 56.25 |
| 75% Flow | 135 | 65.625 |



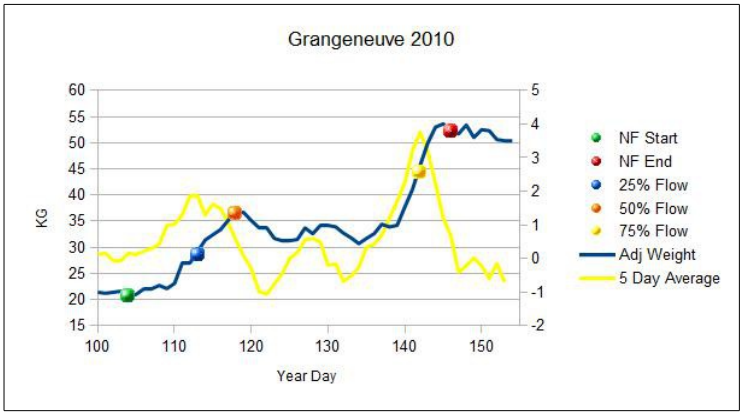

| 2009 NDVI | Year Day | | Value |
|---|---|---|---|
| SOS | 64.032 | Base val | 5430 |
| End | 360.64 | Peak val | 7565 |
| Length | 296.64 | Ampl. | 2135 |
| Peak t | 192.48 | L.deriv. | 547.3 |
| | | R.deriv. | 255.3 |
| | | L.integral | 138500 |
| | | S.integral | 29940 |



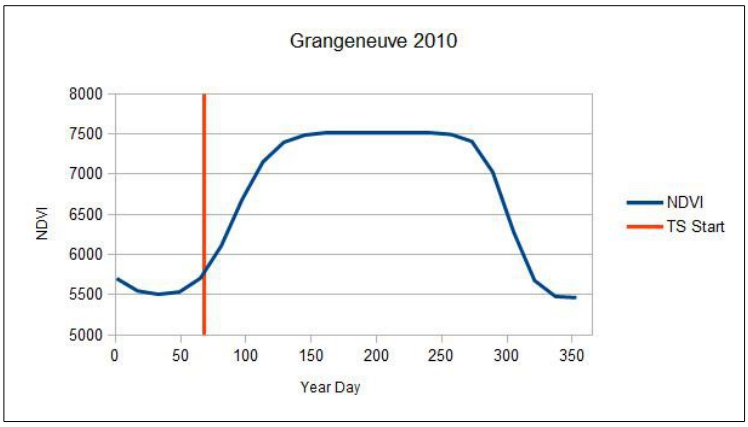

| 2009 | | | |
|---|---|---|---|
| Day | Adj KG | Adj Day | 5 Day Avg |
| 99 | 41.3 | 0 | -0.075 |
| 100 | 41.3 | 0 | -0.04 |
| 101 | 41.2 | -0.1 | -0.02 |
| 102 | 41.3 | 0.1 | -0.02 |
| 103 | 41.2 | -0.1 | -0.16 |
| 104 | 41.2 | 0 | -0.12 |
| 105 | 40.5 | -0.7 | -0.14 |
| 106 | 40.6 | 0.1 | -0.14 |
| 107 | 40.6 | 0 | -0.18 |
| 108 | 40.5 | -0.1 | -0.02 |
| 109 | 40.3 | -0.2 | 0.2 |
| 110 | 40.4 | 0.1 | 0.14 |
| 111 | 41.6 | 1.2 | -0.28 |
| 112 | 41.3 | -0.3 | -0.04 |
| 113 | 39.1 | -2.2 | -0.2 |
| 114 | 40.1 | 1 | -0.92 |
| 115 | 39.4 | -0.7 | -0.92 |
| 116 | 37 | -2.4 | -0.32 |
| 117 | 36.7 | -0.3 | -0.4 |
| 118 | 37.5 | 0.8 | 0.06 |
| 119 | 38.1 | 0.6 | 0.4 |
| 120 | 39.7 | 1.6 | 0.86 |
| 121 | 39 | -0.7 | 0.32 |
| 122 | 41 | 2 | 0.32 |
| 123 | 39.1 | -1.9 | 0.8 |
| 124 | 39.7 | 0.6 | 1.8 |
| 125 | 43.7 | 4 | 1.66 |
| 126 | 48 | 4.3 | 2.58 |
| 127 | 49.3 | 1.3 | 2.86 |
| 128 | 52 | 2.7 | 2.72 |
| 129 | 54 | 2 | 1.8 |
| 130 | 57.3 | 3.3 | 3.16 |
| 131 | 57 | -0.3 | 2.58 |
| 132 | 65.1 | 8.1 | 1.74 |
| 133 | 64.9 | -0.2 | 1.6 |
| 134 | 62.7 | -2.2 | 1.92 |
| 135 | 65.3 | 2.6 | -0.06 |
| 136 | 66.6 | 1.3 | 0.62 |
| 137 | 64.8 | -1.8 | 1.38 |
| 138 | 68 | 3.2 | 1.08 |
| 139 | 69.6 | 1.6 | 0.84 |
| 140 | 70.7 | 1.1 | 1.24 |
| 141 | 70.8 | 0.1 | 0.84 |
| 142 | 71 | 0.2 | 0.76 |
| 143 | 72.2 | 1.2 | 0.86 |
| 144 | 73.4 | 1.2 | 0.48 |
| 145 | 75 | 1.6 | 0.46 |
| 146 | 73.2 | -1.8 | 0.32 |
| 147 | 73.3 | 0.1 | 0.12 |
| 148 | 73.8 | 0.5 | -0.26 |
| 149 | 74 | 0.2 | 0.16 |
| 150 | 73.7 | -0.3 | 0.22 |
| 151 | 74 | 0.3 | 0.12 |
| 152 | 74.4 | 0.4 | 0.08 |
| 153 | 74.4 | 0 | 0.14 |

| Name | X | Y | Ele. (m) | DMEER |
|---|---|---|---|---|
| Posieux (Grangeneuve) | 46.7643 | 7.0977 | 670 | Western European Broadleaf forests |

| 2010 HBNF | Day | Weight (KG) |
|---|---|---|
| NF Start | 104 | 20.6 |
| NF End | 146 | 52.2 |
| NF Duration | 42 | 31.6 |
| Quarter | | 7.9 |
| 25% Flow | 113 | 28.5 |
| 50% Flow | 118 | 36.4 |
| 75% Flow | 142 | 44.3 |



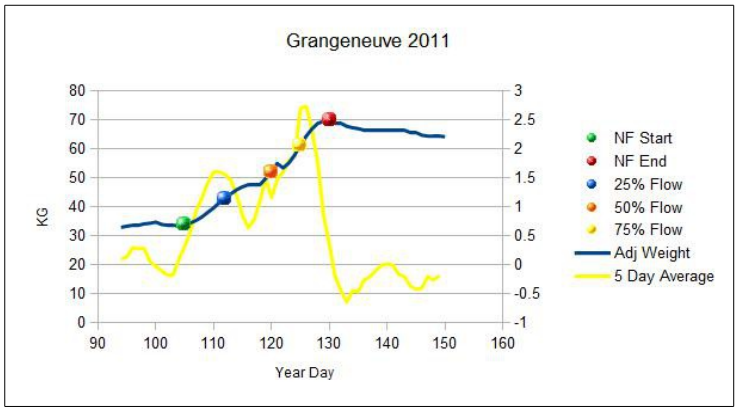

| 2010 NDVI | Year Day | | Value |
|---|---|---|---|
| SOS | 68 | Base val | 5485 |
| End | 317.44 | Peak val | 7513 |
| Length | 249.44 | Ampl. | 2027 |
| Peak t | 197.6 | L.deriv. | 500.3 |
| | | R.deriv. | 655 |
| | | L.integral | 119500 |
| | | S.integral | 26240 |



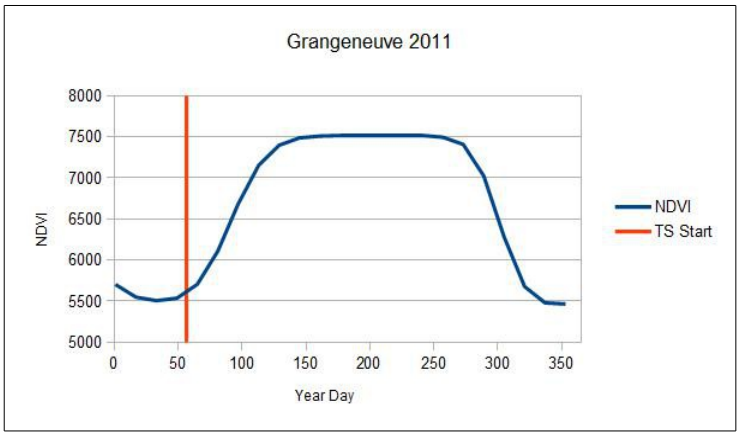

| 2010 | | | |
|---|---|---|---|
| Day | Adj KG | Adj Day | 5 Day Avg |
| 98 | 20.8 | 0 | -0.16 |
| 99 | 20.9 | 0.1 | -0.12 |
| 100 | 21.4 | 0.5 | 0.12 |
| 101 | 21.2 | -0.2 | 0.16 |
| 102 | 21.4 | 0.2 | -0.06 |
| 103 | 21.6 | 0.2 | -0.08 |
| 104 | 20.6 | -1 | 0.16 |
| 105 | 21 | 0.4 | 0.12 |
| 106 | 22 | 1 | 0.22 |
| 107 | 22 | 0 | 0.3 |
| 108 | 22.7 | 0.7 | 0.42 |
| 109 | 22.1 | -0.6 | 0.98 |
| 110 | 23.1 | 1 | 1.02 |
| 111 | 26.9 | 3.8 | 1.3 |
| 112 | 27.1 | 0.2 | 1.86 |
| 113 | 29.2 | 2.1 | 1.86 |
| 114 | 31.4 | 2.2 | 1.3 |
| 115 | 32.4 | 1 | 1.62 |
| 116 | 33.4 | 1 | 1.48 |
| 117 | 35.2 | 1.8 | 1.04 |
| 118 | 36.6 | 1.4 | 0.54 |
| 119 | 36.6 | 0 | 0.08 |
| 120 | 35.1 | -1.5 | -0.3 |
| 121 | 33.8 | -1.3 | -0.98 |
| 122 | 33.7 | -0.1 | -1.06 |
| 123 | 31.7 | -2 | -0.76 |
| 124 | 31.3 | -0.4 | -0.46 |
| 125 | 31.3 | 0 | 0 |
| 126 | 31.5 | 0.2 | 0.18 |
| 127 | 33.7 | 2.2 | 0.56 |
| 128 | 32.6 | -1.1 | 0.6 |
| 129 | 34.1 | 1.5 | 0.48 |
| 130 | 34.3 | 0.2 | -0.2 |
| 131 | 33.9 | -0.4 | -0.16 |
| 132 | 32.7 | -1.2 | -0.68 |
| 133 | 31.8 | -0.9 | -0.52 |
| 134 | 30.7 | -1.1 | -0.26 |
| 135 | 31.7 | 1 | 0.34 |
| 136 | 32.6 | 0.9 | 0.42 |
| 137 | 34.4 | 1.8 | 0.7 |
| 138 | 33.9 | -0.5 | 1.2 |
| 139 | 34.2 | 0.3 | 1.7 |
| 140 | 37.7 | 3.5 | 2.26 |
| 141 | 41.1 | 3.4 | 3.22 |
| 142 | 45.7 | 4.6 | 3.76 |
| 143 | 50 | 4.3 | 3.18 |
| 144 | 53 | 3 | 2.22 |
| 145 | 53.6 | 0.6 | 1.2 |
| 146 | 52.2 | -1.4 | 0.68 |
| 147 | 51.7 | -0.5 | -0.4 |
| 148 | 53.4 | 1.7 | -0.22 |
| 149 | 51 | -2.4 | 0.02 |
| 150 | 52.5 | 1.5 | -0.22 |
| 151 | 52.3 | -0.2 | -0.6 |
| 152 | 50.6 | -1.7 | -0.15 |
| 153 | 50.4 | -0.2 | -0.7 |

| Name | X | Y | Ele. (m) | DMEER |
|---|---|---|---|---|
| Posieux (Grangeneuve) | 46.7643 | 7.0977 | 670 | Western European Broadleaf forests |

| 2011 HBNF | Day | Weight (KG) |
|---|---|---|
| NF Start | 105 | 33.9 |
| NF End | 130 | 70.3 |
| NF Duration | 25 | 36.4 |
| Quarter | | 9.1 |
| 25% Flow | 112 | 43 |
| 50% Flow | 120 | 52.1 |
| 75% Flow | 125 | 61.2 |



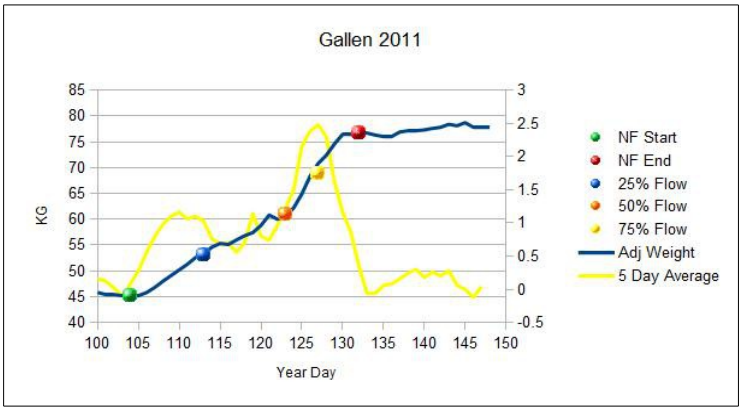

| 2011 NDVI | Year Day | | Value |
|---|---|---|---|
| SOS | 56.16 | Base val | 5461 |
| End | 333.28 | Peak val | 7496 |
| Length | 277.12 | Ampl. | 2035 |
| Peak t | 198.24 | L.deriv. | 715.9 |
| | | R.deriv. | 866.7 |
| | | L.integral | 134900 |
| | | S.integral | 31190 |



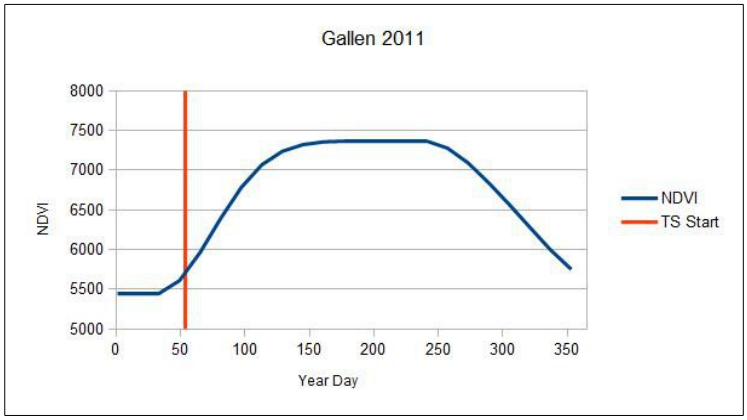

| 2011 | | | |
|---|---|---|---|
| Day | Adj KG | Adj Day | 5 Day Avg |
| 92 | 33.2 | 0 | 0.04 |
| 93 | 32.7 | -0.5 | 0.08 |
| 94 | 33 | 0.3 | 0.1 |
| 95 | 33.4 | 0.4 | 0.14 |
| 96 | 33.7 | 0.3 | 0.3 |
| 97 | 33.9 | 0.2 | 0.28 |
| 98 | 34.2 | 0.3 | 0.28 |
| 99 | 34.4 | 0.2 | 0.06 |
| 100 | 34.8 | 0.4 | -0.02 |
| 101 | 34 | -0.8 | -0.1 |
| 102 | 33.8 | -0.2 | -0.18 |
| 103 | 33.7 | -0.1 | -0.18 |
| 104 | 33.5 | -0.2 | 0.1 |
| 105 | 33.9 | 0.4 | 0.32 |
| 106 | 34.5 | 0.6 | 0.58 |
| 107 | 35.4 | 0.9 | 0.94 |
| 108 | 36.6 | 1.2 | 1.16 |
| 109 | 38.2 | 1.6 | 1.42 |
| 110 | 39.7 | 1.5 | 1.6 |
| 111 | 41.6 | 1.9 | 1.6 |
| 112 | 43.4 | 1.8 | 1.56 |
| 113 | 44.6 | 1.2 | 1.46 |
| 114 | 46 | 1.4 | 1.2 |
| 115 | 47 | 1 | 0.86 |
| 116 | 47.6 | 0.6 | 0.64 |
| 117 | 47.7 | 0.1 | 0.78 |
| 118 | 47.8 | 0.1 | 1.1 |
| 119 | 49.9 | 2.1 | 1.5 |
| 120 | 52.5 | 2.6 | 1.16 |
| 121 | 55.1 | 2.6 | 1.48 |
| 122 | 53.5 | -1.6 | 1.6 |
| 123 | 55.2 | 1.7 | 1.8 |
| 124 | 57.9 | 2.7 | 1.88 |
| 125 | 61.5 | 3.6 | 2.7 |
| 126 | 64.5 | 3 | 2.74 |
| 127 | 67 | 2.5 | 2.34 |
| 128 | 68.9 | 1.9 | 1.76 |
| 129 | 69.6 | 0.7 | 0.86 |
| 130 | 70.3 | 0.7 | 0.36 |
| 131 | 68.8 | -1.5 | -0.2 |
| 132 | 68.8 | 0 | -0.44 |
| 133 | 67.9 | -0.9 | -0.64 |
| 134 | 67.4 | -0.5 | -0.44 |
| 135 | 67.1 | -0.3 | -0.46 |
| 136 | 66.6 | -0.5 | -0.26 |
| 137 | 66.5 | -0.1 | -0.2 |
| 138 | 66.6 | 0.1 | -0.1 |
| 139 | 66.4 | -0.2 | 0 |
| 140 | 66.6 | 0.2 | 0.02 |
| 141 | 66.6 | 0 | 0 |
| 142 | 66.6 | 0 | -0.16 |
| 143 | 66.6 | 0 | -0.2 |
| 144 | 65.6 | -1 | -0.36 |
| 145 | 65.6 | 0 | -0.42 |
| 146 | 64.8 | -0.8 | -0.4 |
| 147 | 64.5 | -0.3 | -0.2 |

| Name | X | Y | Ele. (m) | DMEER |
|---|---|---|---|---|
| St. Gallen | 47.4251 | 9.3766 | 671 | Western European Broadleaf forests |

| 2011 HBNF | Day | Weight (KG) |
|---|---|---|
| NF Start | 104 | 45.1 |
| NF End | 132 | 76.6 |
| NF Duration | 28 | 31.5 |
| Quarter | | 7.875 |
| 25% Flow | 113 | 52.975 |
| 50% Flow | 123 | 60.85 |
| 75% Flow | 127 | 68.725 |



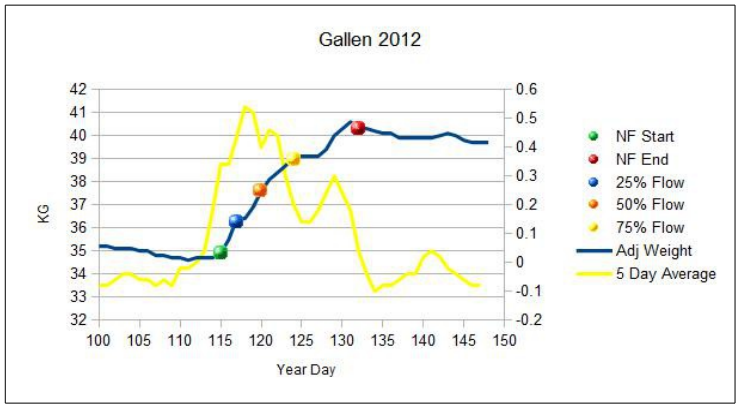

| 2011 NDVI | Year Day | | Value |
|---|---|---|---|
| TS Start 15% | 56.16 | Base val | 5442 |
| End 15% | 333.28 | Peak val | 7373 |
| Length | 277.12 | Ampl. | 1931 |
| Peak t | 198.24 | L.deriv. | 374.6 |
| | | R.deriv. | 271.2 |
| | | L.integral | 142000 |
| | | S.integral | 27690 |



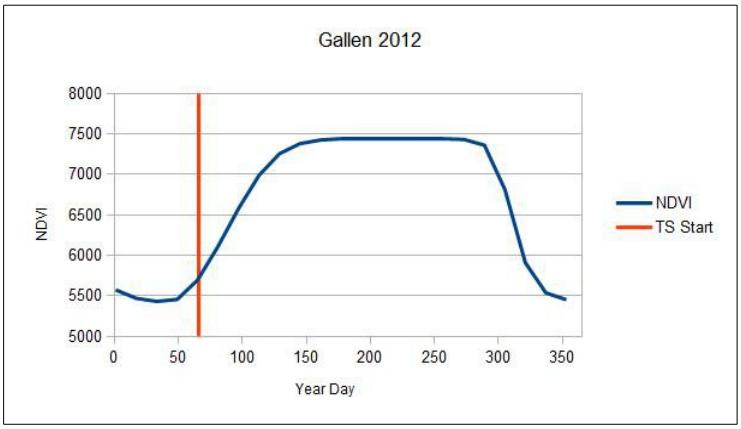

| 2011 | | | |
|---|---|---|---|
| Day | Adj KG | Adj Day | 5 Day Avg |
| 90 | 44.5 | 0 | |
| 91 | 44.5 | 0 | -0.025 |
| 92 | 44.4 | -0.1 | -0.02 |
| 93 | 44.4 | 0 | -0.04 |
| 94 | 44.4 | 0 | -0.04 |
| 95 | 44.3 | -0.1 | 0.04 |
| 96 | 44.3 | 0 | 0.04 |
| 97 | 44.6 | 0.3 | 0.12 |
| 98 | 44.6 | 0 | 0.3 |
| 99 | 45 | 0.4 | 0.22 |
| 100 | 45.8 | 0.8 | 0.16 |
| 101 | 45.4 | -0.4 | 0.12 |
| 102 | 45.4 | 0 | 0.02 |
| 103 | 45.2 | -0.2 | -0.1 |
| 104 | 45.1 | -0.1 | 0.08 |
| 105 | 45.3 | 0.2 | 0.28 |
| 106 | 45.8 | 0.5 | 0.56 |
| 107 | 46.8 | 1 | 0.8 |
| 108 | 48 | 1.2 | 0.98 |
| 109 | 49.1 | 1.1 | 1.1 |
| 110 | 50.2 | 1.1 | 1.16 |
| 111 | 51.3 | 1.1 | 1.06 |
| 112 | 52.6 | 1.3 | 1.1 |
| 113 | 53.3 | 0.7 | 1.02 |
| 114 | 54.6 | 1.3 | 0.76 |
| 115 | 55.3 | 0.7 | 0.68 |
| 116 | 55.1 | -0.2 | 0.7 |
| 117 | 56 | 0.9 | 0.56 |
| 118 | 56.8 | 0.8 | 0.7 |
| 119 | 57.4 | 0.6 | 1.14 |
| 120 | 58.8 | 1.4 | 0.8 |
| 121 | 60.8 | 2 | 0.74 |
| 122 | 60 | -0.8 | 0.96 |
| 123 | 60.5 | 0.5 | 1.22 |
| 124 | 62.2 | 1.7 | 1.5 |
| 125 | 64.9 | 2.7 | 2.16 |
| 126 | 68.3 | 3.4 | 2.38 |
| 127 | 70.8 | 2.5 | 2.48 |
| 128 | 72.4 | 1.6 | 2.3 |
| 129 | 74.6 | 2.2 | 1.62 |
| 130 | 76.4 | 1.8 | 1.16 |
| 131 | 76.4 | 0 | 0.86 |
| 132 | 76.6 | 0.2 | 0.34 |
| 133 | 76.7 | 0.1 | -0.06 |
| 134 | 76.3 | -0.4 | -0.06 |
| 135 | 76.1 | -0.2 | 0.06 |
| 136 | 76.1 | 0 | 0.08 |
| 137 | 76.9 | 0.8 | 0.16 |
| 138 | 77.1 | 0.2 | 0.24 |
| 139 | 77.1 | 0 | 0.3 |
| 140 | 77.3 | 0.2 | 0.18 |
| 141 | 77.6 | 0.3 | 0.26 |
| 142 | 77.8 | 0.2 | 0.2 |
| 143 | 78.4 | 0.6 | 0.28 |
| 144 | 78.1 | -0.3 | 0.06 |
| 145 | 78.7 | 0.6 | 0 |
| 146 | 77.9 | -0.8 | -0.12 |
| 147 | 77.8 | -0.1 | 0.04 |
| 148 | 77.8 | 0 | -0.06 |
| 149 | 78.3 | 0.5 | -0.02 |
| 150 | 78.4 | 0.1 | -0.02 |
| 151 | 77.8 | -0.6 | 0.02 |
| 152 | 77.7 | -0.1 | 0.02 |
| 153 | 77.9 | 0.2 | -0.04 |
| 154 | 78.4 | 0.5 | 0.04 |
| 155 | 78.2 | -0.2 | 0.18 |
| 156 | 78 | -0.2 | 0.06 |
| 157 | 78.6 | 0.6 | -0.1 |

| Name | X | Y | Ele. (m) | DMEER |
|---|---|---|---|---|
| St. Gallen | 47.4251 | 9.3766 | 671 | Western European Broadleaf forests |

| 2012 HBNF | Day | Weight (KG) |
|---|---|---|
| NF Start | 115 | 34.9 |
| NF End | 132 | 40.3 |
| NF Duration | 17 | 5.4 |
| Quarter | | 1.35 |
| 25% Flow | 117 | 36.25 |
| 50% Flow | 120 | 37.6 |
| 75% Flow | 124 | 38.95 |




| 2012 NDVI | Year Day | | Value |
|---|---|---|---|
| Start | 65.44 | Base val | 5436 |
| End | 327.2 | Peak val | 7441 |
| Length | 261.92 | Ampl. | 2005 |
| Peak t | 206.08 | L.deriv. | 422.6 |
| | | R.deriv. | 750.6 |
| | | L.integral | 125100 |
| | | S.integral | 27290 |




| 2012 | | | |
|---|---|---|---|
| Day | Adj KG | Adj Day | 5 Day Avg |
| 90 | 35.7 | -0.1 | -0.06 |
| 91 | 35.6 | -0.1 | -0.06 |
| 92 | 35.6 | 0 | -0.06 |
| 93 | 35.5 | -0.1 | -0.02 |
| 94 | 35.5 | 0 | 0 |
| 95 | 35.6 | 0.1 | -0.02 |
| 96 | 35.6 | 0 | 0 |
| 97 | 35.5 | -0.1 | -0.02 |
| 98 | 35.5 | 0 | -0.08 |
| 99 | 35.4 | -0.1 | -0.08 |
| 100 | 35.2 | -0.2 | -0.08 |
| 101 | 35.2 | 0 | -0.08 |
| 102 | 35.1 | -0.1 | -0.06 |
| 103 | 35.1 | 0 | -0.04 |
| 104 | 35.1 | 0 | -0.04 |
| 105 | 35 | -0.1 | -0.06 |
| 106 | 35 | 0 | -0.06 |
| 107 | 34.8 | -0.2 | -0.08 |
| 108 | 34.8 | 0 | -0.06 |
| 109 | 34.7 | -0.1 | -0.08 |
| 110 | 34.7 | 0 | -0.02 |
| 111 | 34.6 | -0.1 | -0.02 |
| 112 | 34.7 | 0.1 | 0 |
| 113 | 34.7 | 0 | 0.04 |
| 114 | 34.7 | 0 | 0.18 |
| 115 | 34.9 | 0.2 | 0.34 |
| 116 | 35.5 | 0.6 | 0.34 |
| 117 | 36.4 | 0.9 | 0.44 |
| 118 | 36.4 | 0 | 0.54 |
| 119 | 36.9 | 0.5 | 0.52 |
| 120 | 37.6 | 0.7 | 0.4 |
| 121 | 38.1 | 0.5 | 0.46 |
| 122 | 38.4 | 0.3 | 0.44 |
| 123 | 38.7 | 0.3 | 0.3 |
| 124 | 39.1 | 0.4 | 0.2 |
| 125 | 39.1 | 0 | 0.14 |
| 126 | 39.1 | 0 | 0.14 |
| 127 | 39.1 | 0 | 0.18 |
| 128 | 39.4 | 0.3 | 0.24 |
| 129 | 40 | 0.6 | 0.3 |
| 130 | 40.3 | 0.3 | 0.24 |
| 131 | 40.6 | 0.3 | 0.18 |
| 132 | 40.3 | -0.3 | 0.04 |
| 133 | 40.3 | 0 | -0.04 |
| 134 | 40.2 | -0.1 | -0.1 |
| 135 | 40.1 | -0.1 | -0.08 |
| 136 | 40.1 | 0 | -0.08 |
| 137 | 39.9 | -0.2 | -0.06 |
| 138 | 39.9 | 0 | -0.04 |
| 139 | 39.9 | 0 | -0.04 |
| 140 | 39.9 | 0 | 0.02 |
| 141 | 39.9 | 0 | 0.04 |
| 142 | 40 | 0.1 | 0.02 |
| 143 | 40.1 | 0.1 | -0.02 |
| 144 | 40 | -0.1 | -0.04 |
| 145 | 39.8 | -0.2 | -0.06 |
| 146 | 39.7 | -0.1 | -0.08 |

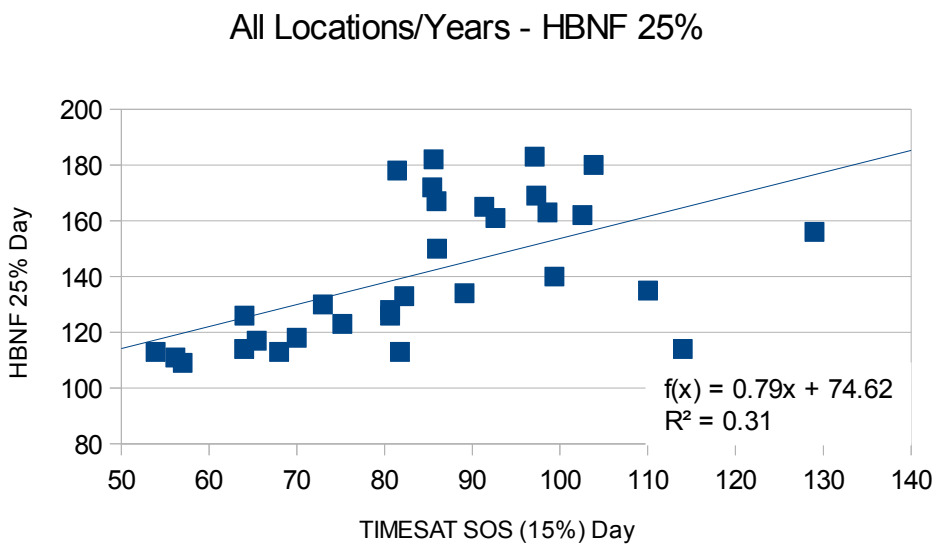



*Figure 1 : All Locations/Years – HBNF 25%, n=31*

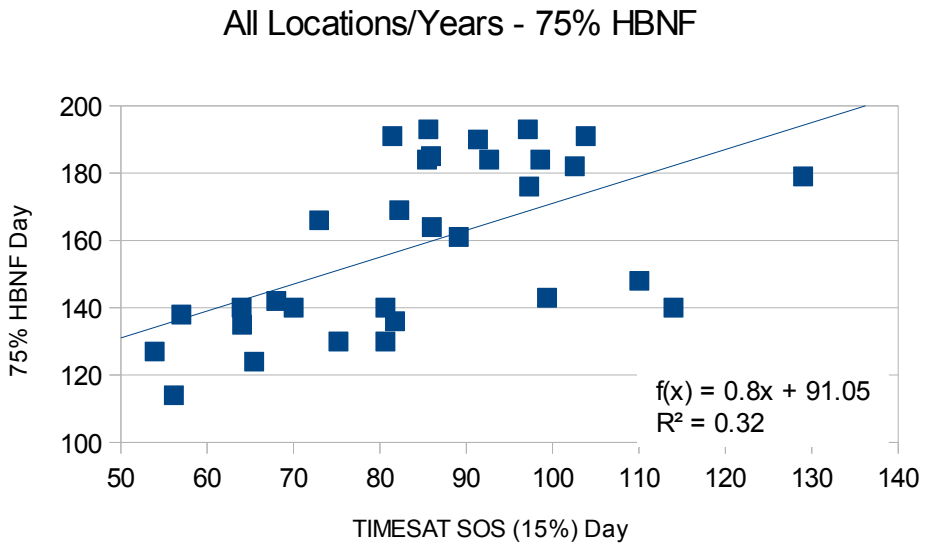



*Figure 2: All Locations/Years – HBNF 75%, n=31*

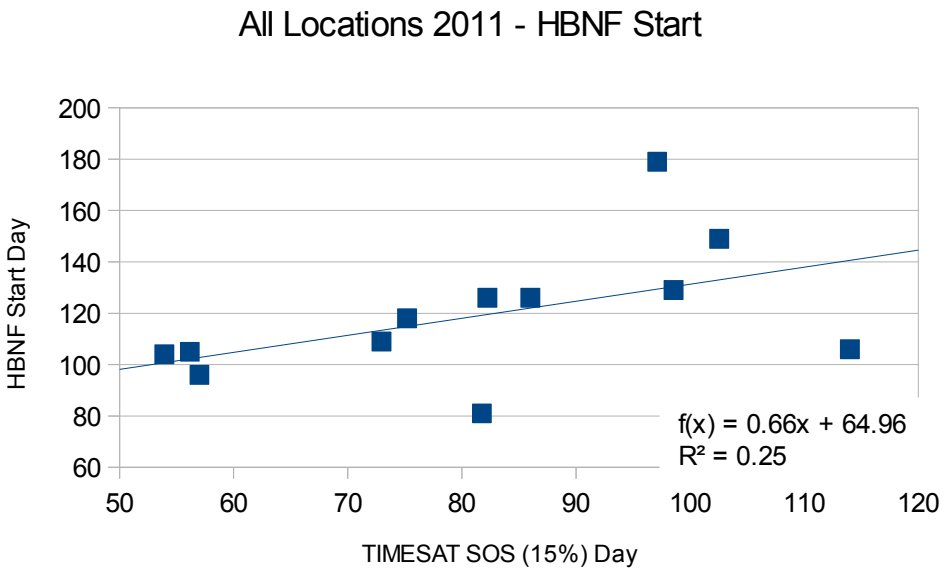



*Figure 3: All Locations 2011 – HBNF Start, n=12*

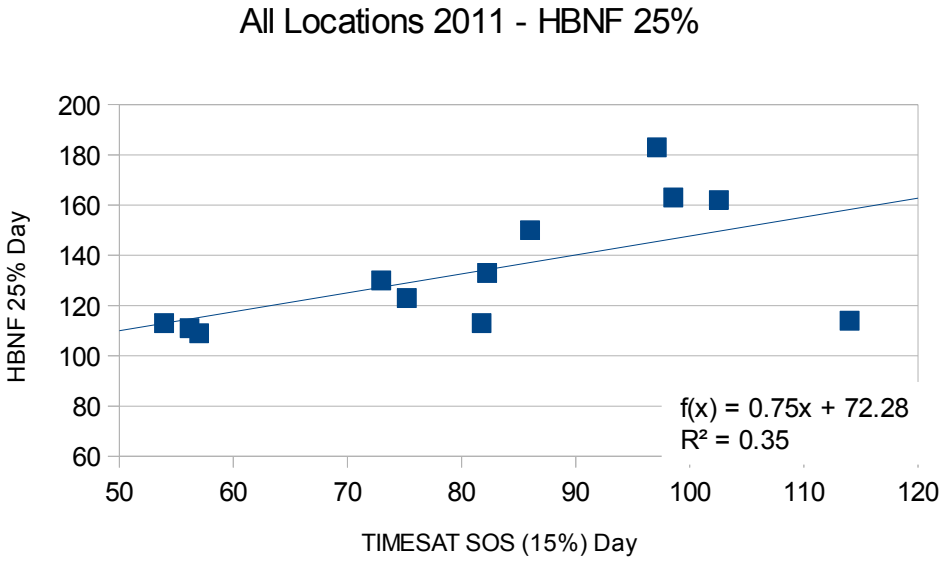



*Figure 4: All Locations 2011 – HBNF 25%, n=12*

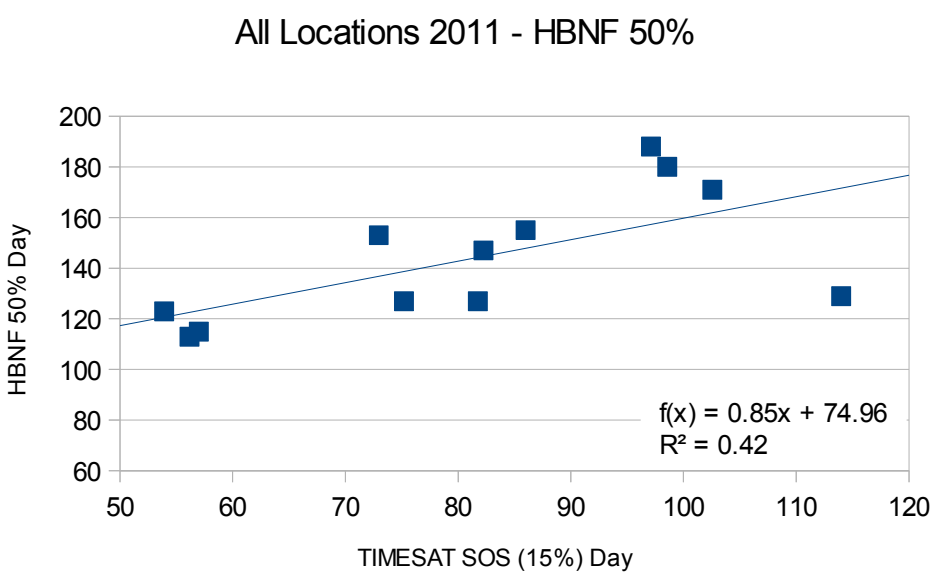



*Figure 5: All Locations 2011 - HBNF 50%*

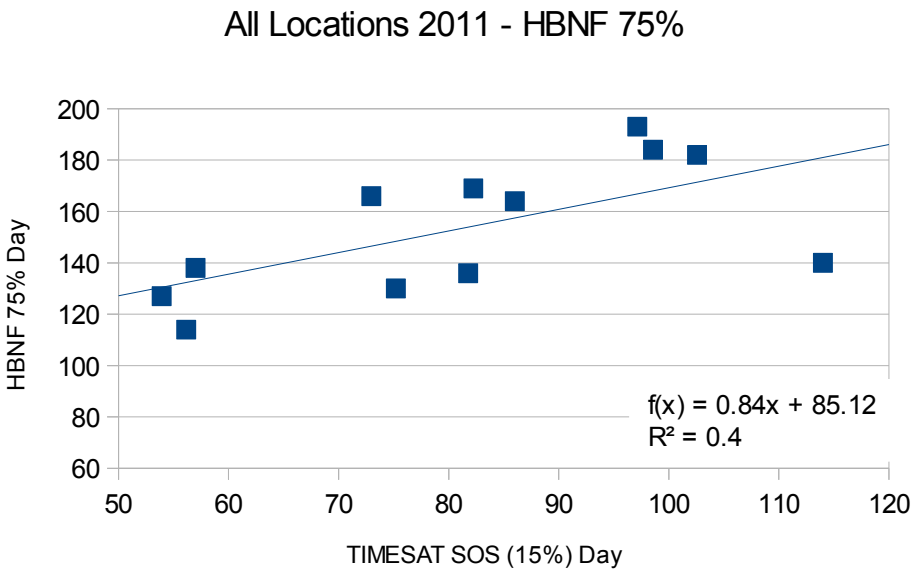



*Figure 6: All Locations/Years – HBNF 75%, n=31*

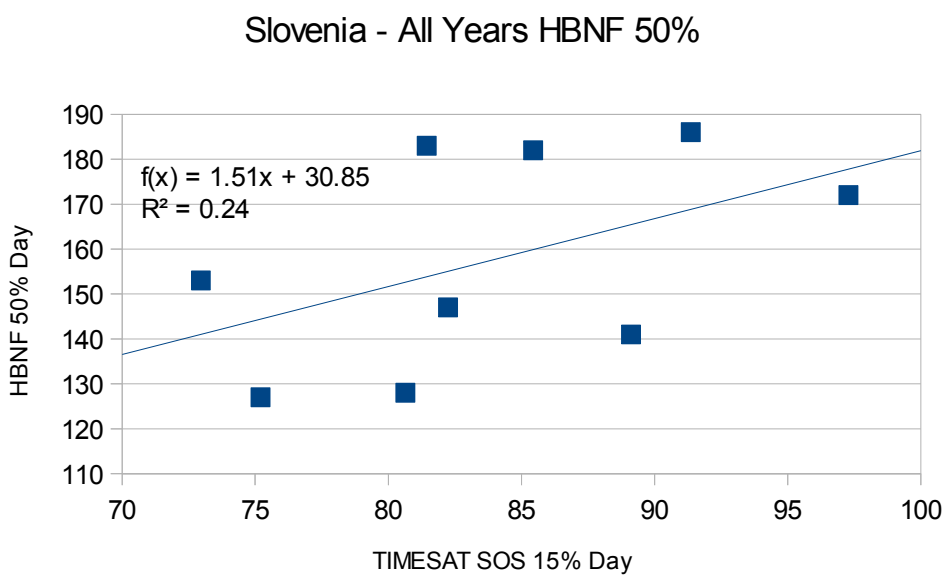



*Figure 7: Slovenia – All Years HBNF 50%, n=9*

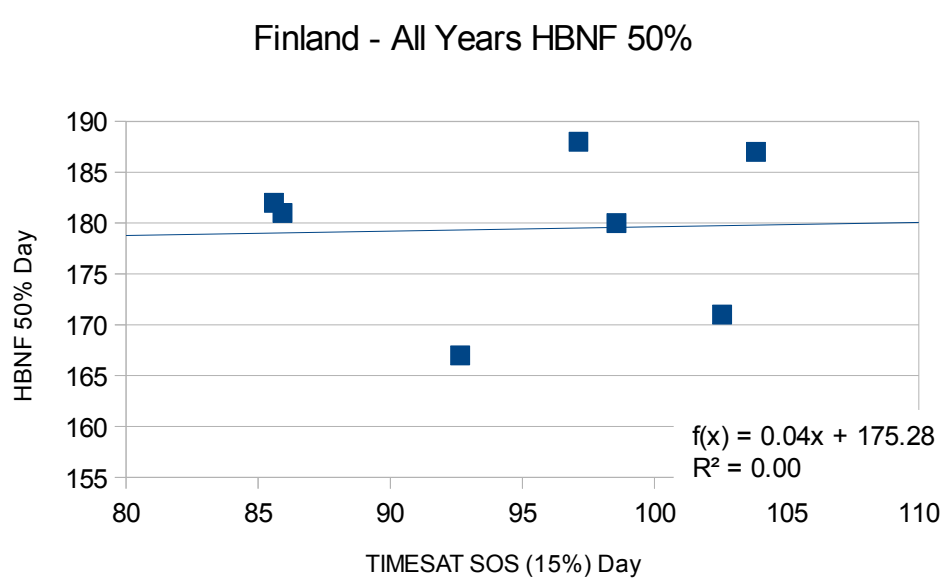



*Figure 8: Finland – All Years HBNF 50%, n=7*

| Data | File Type | Location |
|---|---|---|
| HBNF Totals | LibreOffice Spreadsheet | M:\diss_final\hbnf_totals.ods |
| Scale-Hive | LibreOffice Spreadsheet | M:\diss_final\hbnf\ |
| NDVI Data | ASCII | M:\diss_final\ndvi |
| LST Data | ASCII | M:\diss_final\lst |
| Hive Locations | Shapefile | M:\diss_final\gis\hivepoints.shp |
| DMEER | MS Database | M:\diss_final\gis\dmeereea4074i.mdb |
| | | |
| Program | | |
| TIMESAT | ZIP | M:\diss_final\timesat311_nostandalone.zip |