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Forest management for the future of Nordic and Baltic forests – increased biomass production, adaptation to climate change, and increased CO_2 absorption and storage

SNS/Efinord Growth and Yield Network Conference

BOOK OF ABSTRACTS

June 13th – 15th, 2017

Drøbak, Hurdal and Son, Norway

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Cover page: Presentation in Hurdal forest. Photo Lars Dalen.

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Innhold

Foreword

About half of the area in the Nordic and Baltic countries (Denmark, Norway, Sweden, Finland, Iceland, Estonia, Latvia and Lithuania) is dominated by forest land and the total productive forest area is about 63 mill. ha in the countries. The annual increment is about 280 mill m3. In Iceland, only a minor part is covered by forest. The forests of the Nordic and Baltic countries are very important resources and support the building sector, the wood processing industry and the energy sector. The forest resources are extensively utilized and contribute significantly to the economy in these countries. In addition, the forest is a crucial ecosystem and several ecosystem services are based on forest trees.

Today, several aspects and concerns about forests are arising. Can a changed climate affect current growth and yield? Is increased forest biomass production possible? In this Nordic/Baltic conference we want to address some important growth and yield subjects.

- Adapting forest management and new silvicultural methods to a changed climate
- Use of forest for both CO2 absorption and CO_2 storage
- Forest production/products for bioenergy to substitute fossil fuel
- Increase forest production and timber quality to improve the bioeconomy
- Improve the outputs from forest including ecosystem services

The conference program includes both indoor and outdoor presentations. We visit practical field trials in the forest in Hurdal and Son municipality. The indoor presentations take place in Drøbak close to Ås where Norwegian University of Life Sciences and Norwegian Institute of Bioeconomy research (NIBIO) is situated.

The conference will provide an overview and examples of the latest research in growth and yield research relevant for North European countries. This is an important platform for G&Y scientists to meet and to discuss scientific questions, to share knowledge, to build networks and to work out ideas for possible common applications and projects.

The conference is financed by the Nordic Forest Research (SNS). SNS is a cooperating body financed with Nordic funds under the auspices of the Nordic Council of Ministers. The overall purpose of SNS is to promote research that highlights the diverse functions of the forests in sustainable forestry, as well as to advise the Nordic Council of Ministers on questions concerning forests and forest research. Through foresighted activities in research co-operation and communication of knowledge, SNS aims to contribute to the socially, economically and ecologically responsible management and utilization of forests and wood resources in the Nordic region.

Discussions before conference dinner at Oscarsborg Fortress. Photo Kjell Andreassen.

Programme

Time	*Tuesday June 13*
ca 11:30	Meeting at Oslo Airport
12:00	Bus to Hurdal (34 km)
12:30	Lunch in the forest in Hurdal (picnic)
13:30	Excursion to a Level 2 monitoring experimental site
	Holger Lange: Carbon exchange measurements at a flux tower in Hurdal
	Wenche Aas: Monitoring of long range transboundary air pollution. The measurements at Hurdal in an international perspective
	Nicholas Clarke: Chemical elements in precipitation, canopy throughfall and soil water
	Kjell Andreassen: Variation of Norway spruce growth within a season and correlations with climate
	Micky Allen: Development and growth in a mixed Norway spruce and Scots pine site
14:45	Bus 5 min to a long term mixed spruce/pine experimental site
16:00	Bus to Hotel Reenskaug in Drøbak (11 km west of Ås)
	http://www.reenskaug.no
19:00	Dinner in Drøbak
21:00	Voluntary walk in old town and harbour
	Wednesday June 14
08:00	Indoor presentations
12:00	Lunch at the hotel
13:00	Bus to a forest experiment in Kolås near Son in Østfold
13:30	Excursion and demonstration of the experimental site
	Per Kristian Rørstad and *Bjørn Nordén*: Transformation of recent forest on abandoned agricultural land for the benefit of biodiversity, ecosystem services and green solutions – TRANSFOREST
15:00	Bus back to hotel
18:05	Boat from Sundbrygga to Oscarsborg Fortress (10 min) Oscarsborg festning
18:15	Sightseeing at Oscarsborg Fortress, the location of a historical and dramatic fight in the beginning of World War 2
20:00	Conference dinner at Oscarsborg Fortress
22:45	Boat back to Drøbak
	Thursday June 15
08:00	Indoor presentations
12:00	Lunch at the hotel
13:00	Discussion. Closing remarks. Next meeting
14:15	Public transport (ca 1 1/2 hour) to Oslo Airport Gardermoen
17:00	Flight and return home

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Long-term growth response of Scots pine (Pinus sylvestris L.) to changing site conditions: a case study of North-East Estonia

Aleksei Potapov.[1], Hordo, M.[1]

1) Department of Forest Management, Institute of Forestry and Rural Engineering, Estonian University of Life Sciences, Tartu, Estonia

In order to improve forest growth conditions, water management was actively applied during 20th century in Fennoscandia, Baltics and Russia by using networks of open ditches. In case of Estonia, total area of (artificially) drained stands is currently ca 30% of forest land. Carbon storage and greenhouse gas (GHG) balance of forest stands growing on organic soils with altered water regime is a rather controversial topic. Contradictory findings may be caused by the fact that peatlands are very diverse and dynamic ecosystems. Whether GHG balance of drained peatland is positive or negative strongly depends on the productivity of forest stands: above and below-ground biomass formation. Hence, to be able to describe and predict growth dynamics of drained stands with adequate accuracy and temporal resolution is of extreme importance.

The aim of the current study is to estimate the long-term growth response of Scots pine trees to drainage operations (original ditching and ditch network maintenance) in case of Estonia. A ditch network with available records of site history was selected as a case study. Growth of 140 sample trees located within 10 forest stands (medium productive, on deep peat soils) was retrospectively analysed by using dendrochronological techniques (based on ring-width data derived from increment cores). Spatial, temporal and structural patterns of tree growth variations related to the effect of drainage were assessed.

Preliminary results suggest that drainage-induced additional diameter increment is related (negatively) more to pre-drainage tree size (described as inside bark diameter at breast height) than to calendar age of a tree. Contrary to previous research, no significant relationship between tree growth (and also time lag of growth response) and distance to the nearest ditch was found.

Occurrences of relative growth responses of similar magnitude were identified both before and after the installation of amelioration system. Hence, it is possible, that post-drainage major growth release (relative growth change of more than 50%) was not caused only by ditching, but also by natural events (e.g. groundwater fluctuations), since in pre-drainage period it cannot be associated with effect of drainage. Further research should be conducted at the countrywide level approaching effects of ditch network maintenance on tree and stand growth, which would suggest optimal forest management regime on drained peatlands from the perspective of GHG balance.

An open source single tree simulator: the R package sitree

Clara Antón Fernández
Norwegian Institute of Bioeconomy Research

With focus on flexibility and memory efficiency sitree is a newly developed cross-platform, open-source individual tree simulator intended to facilitate accurate and flexible simulation of forest dynamics, growth, impact analyses of changes in climate, and forest management. sitree is an R Package, entirely written in R and available at CRAN. R is a popular tool among forestry researchers to perform statistical data analysis and develop new models. Some of these models are used to predict forest growth and production, and to compare yield under different management regimes or climate change scenarios. sitree provides a tool to run simulations and test new functions within R, in a memory efficient way, allowing for long simulations with large datasets. All main functions are to be defined and provided by the user, but we have included example functions to serve as guides in terms of inputs and outputs required for the growth, mortality, recruitment, and management functions.

Tree vitality assessment on forest permanent plots in Estonia

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The root rot caused by *Heterobasidion* spp. and *Armillaria* spp. is considered as the most important forest disease in Estonia causing serious concern in forest management. The majority of trees infected by forest pathogens lack of easily detectable visual symptoms which makes it difficult to discover the occurrence of a decay in a tree. We assessed the health condition of visually healthy trees in regularly managed Norway spruce and Scots pine stands on fertile sites with resistography and found that 8.0% of Norway spruces and 1.6% of Scots pines had well-developed decay on the root collar despite of having any visual symptoms of internal damage. Visually healthy trees growing on permanent forest land experienced more decay than trees growing on former agricultural land. Radial growth of damaged trees was 21% lower in Norway spruces and 13% lower in Scots pines compared to healthy trees, yet this difference in tree growth was statistically not significant. Resistography is the sensible way for allocating the proportion of decayed trees among visually healthy ones. Only by visual assessment, the proportion of damaged trees can be underestimated which may probably lead to miscalculation of tree growth and mortality predictions.

Keywords: Norway spruce, Scots pine, forest health, root rot, resistography, tree growth

Forest management and carbon balance

Hannu Salminen,
Luke, Finland

Climate change mitigation and adaptation induces two goals for forest management; increase both carbon sequestration and the utilization of renewable resources. Are these goals matching or conflicting? What should be considered when assessing the role of forest management in climate policy?

In principle, carbon balance of forests is a simple game. Carbon sequestrates to standing stock in growth process while cuttings and mortality decrease carbon pool over time. Cutting residues, litter, and dead wood first increase soil carbon and then more or less slowly decay. From the forest management perspective, three important dimensions of this game are time, area, and management intensity. Considering the whole carbon cycle, further downstream processing of forest products and their life cycle are important factors, which are partly and indirectly connected also to the actual forest management decisions.

Forest development in Scandinavia is relatively slow and consequences follow decisions with a delay of several decades. The timing of carbon sequestration, cuttings, mortality and decomposition, and the life cycle of wood and wood-based products and their possible substitution effect should all be taken into account. Equally important is to consider the time frame of political decisions concerning forestry and the carbon balance of forests. Are we aiming at short-term or long-term results?

Deforestation is not an issue in Scandinavia but how effectively the growth potential of our forest land is currently used? Is it possible to increase carbon sequestration by renewing forests into fully stocked and rapid growing stands? Does intensive forest management on dedicated areas give room for extensive management and total conservation on others?

To what extent it is possible to increase growth by intensive forest management? What is the effect of extensive management and total conservation on mortality of trees? What management and rotation times yields the maximum carbon storage? How does it affect profitability?

This all comes down to a very basic question; what is the baseline defined by time, area and management intensity when assessing the effect of forest management decisions on carbon balance?

More than giving answers, we raise questions and present three different attempts to approach forest management and carbon balance;

- The effect of management options on carbon dynamics of one initially fully stocked stand
- Optimizing forest management of a stand for combined carbon storage and timber production
- Intensified forest management at national level

Pre- or anti-commercial thinning?

Harald Kvaalen, Gunnhild Søgaard and Aksel Granhus
Norwegian Institute of Bioeconomy Research

Pre-commercial thinning down regulates the number of trees per hectare to transfer the future growth to the remaining trees with the aim of increasing their volume and value. However, reduction in the number of trees also leads to reduced volume growth per hectare. Thus, if the reduced logging cost and higher price of larger saw logs does not balance the loss of volume production and the capital cost of cutting young trees, pre-commercial thinning may turn into an anti-commercial activity. We will present data from a Norwegian pre-commercial thinning trial and show that given the current top diameter measurement of sawn timber, the price premium for larger diameter logs in one Norwegian and one Swedish price table is not likely to be sufficient to balance the production loss from down regulating the initial stand density from 2070 to 1600, 1100, or 820 trees per hectare.

Predicting environment-induced growth changes in growth and yield models

Jari Hynynen
Luke, Finland

According to the results of Finnish National Forest Inventories, growth of forests in Finland has increased 81 % during the last 40 years. In recent study of Henttonen et al. (2017) found out that 63 % of the change was attributed to amount and structure of growing stock affected by forest management. The rest of the volume increment increase (37 %) was environment-induced. Changes in environment-induced increment showed similarities with climatic variation, such as changes growing season temperature sums.

In our presentation we assess possibilities and methods of applying above mentioned findings and analysis approach in modelling climatic effects on forest growth and yield. We address alternatives of introducing the climate change effect into our current analysis and decision support tools which are widely applied in regional and national scale analyses on the development of forests resources under varying management scenarios in changing climate. They introduced an analysis approach for assessing the data. National forest inventory data have been recently applied

From 1971–1975 to 2006–2010, the environment-induced volume increment increase was estimated to be 8.98 million m3 a1 (0.69 m3 ha1 a1), which equals to 37% of the total observed volume increment increase. A large shift was observed after the mid-1990s in all regions.

While the environment-induced increment change was substantial, a considerably larger increase representing 63% of the change was attributed to growing stock volume and forest structure, which both changed due to differences in forest management.
A comparison between the environment-induced increment changes and growing season temperature sums revealed similarities.

Optimization of juvenile stand management regimen for Norway spruce in Finland

Karri Uotila
Luke, Natural Resources Institute Finland

Norway spruce (Picea abies L. Karst) planting is the most common establishment method of forest stands in Finland. Efficient juvenile stand management makes the most out of these stands and has thus a large impact on future yields of wood production. However, during the past decades, we've been living in the era of rather high increase of labor costs and, on the other hand, poor development of roundwood prices on the market. This development has left it's mark on silviculture; Investments in heavily human powered activities, such as juvenile stand management, have lost their appeal. To attain it back, the most efficient management regimens to cut the cost and increase productivity has to be figured out and informed for wood producers.

In recent studies, we've found that two stage management regimen, including early cleaning and pre-commercial thinning (PCT), can be economically viable management method. Spruce stands commonly require early cleaning much sooner than PCT is appropriate to be done. And when early cleaning is required, it enhances diameter growth of released stems quite suddenly. We've also found that labor consumption in PCT increases rapidly with growth of unmanaged stand. Thus, there is no reason to delay the PCT after the point when the released trees are free to grow till the first commercial thinning. Furthermore, juvenile stand management activities are interrelated with the earlier silvicultural activities. Considering these earlier effects can lead to substantial savings in juvenile stand management.

Climate change and growth in Norway spruce in Norway

Kjell Andreassen 1) and Ole Einar Tveito 2)

1) Norwegian Institute of Bioeconomy Research

2) The Norwegian Meteorological Institute

We correlated annual tree growth with climatic variables and made response functions. These response functions were then tested in a second step with values of future scenarios of climate in Norway. Tree growth was estimated from standardised tree ring indices in Norway spruce (NS) from 500 plots scattered in forest area of Norway. The climatic variables were estimated as annual mean month values of temperature, precipitation and Palmer drought severity index (PDSI) geographically interpolated to each of the plots by the Norwegian Meteorological Institute. Several kinds of response functions were developed, and we selected one function for each plot.

In the first step models we experienced that the temperatures and precipitation of May, June and July, and the PDSI of July and August turned out to be the most significant climatic variables for diameter growth. We experienced some different responses on the same variable in different geographical regions. By splitting Norway in four regions we experienced that NS in Western and Northern Norway and in higher altitudes of Eastern Norway responded negatively on higher precipitation. In the lowlands of Eastern Norway the response was opposite with a positive correlation of June precipitation.

In the second step we used the response models to estimate the deviation of the growth in a normal climate (the mean of the 1961-1990 period) versus the growth in a future climate (2071-2100 scenario). In these analyses we concluded a general increase in growth of Norway spruce for most locations. The highest growth increase is expected in Northern Norway and in the higher altitudes of Eastern Norway with about 18 %. In Western Norway and in the lowlands of Eastern Norway a positive growth increase of about 12 % is expected for 2071 to 2100. A main reason for the increased growth reaction is the increased precipitation in the early summer which is very important for the growth sensitive Norway spruce.

Key words: Norway spruce, tree rings, growth, climate, scenarios

Effects of repeated fertilization in young Norway spruce forests

Kjersti Holt Hanssen and Harald Kvaalen 1)
Norwegian Institute of Bioeconomy Research

There are a number of studies in the Nordic countries demonstrating the positive effect of fertilization on conifer growth. In old stands of Norway spruce and Scots pine, experiments generally show that N is the only element to give a significant growth increase. However, in young stands also elements like P and K have been found to have a positive effect.

In 1983, an experiment in 28 young Norway spruce thinning stands was initiated in central Norway, aiming at testing if a complete mixture of different nutrients would give additional growth compared to adding only N. The treatments consisted of control plots that were thinned, but not fertilized, fertilization with 150 kg N ha-1 (150 N), and fertilization with 150 kg N plus addition of P, K, Mg, B, Mn and Cu (150 N+mix). At the first fertilization, breast height age varied between 12 and 39 years. The stands were fertilized three times with approximately eight years interval.

Our results show that overall there was a positive effect on volume increment of the 150N and 150N+mix treatment. On average, the volume increment was 13 % higher for 150 N compared to control plots, while for 150 N + mix the increase was 24 %.The effect on growth increment was highest the first fertilization period. Vegetation type did not affect growth. The effect of fertilization was strongest for the plots at the highest altitude, > 300 m a.s.l., and these plots also responded best to the 150N+mix treatment. This effect may be related to differences in the chemical composition of the bedrock in the area.

Post-disturbance natural forest regeneration in Estonia

Marek Metslaid.
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In two hemiboreal mixed spruce–hardwood forests in north-east Estonia, we studied factors that affect tree regeneration survival and development during the first post-storm decade, and how these effects change in time. Regeneration height and mortality of the common (hemi)boreal forest tree species black alder (Alnus glutinosa (L.) J. Gaertn.), birch (Betula pendula Roth., Betula pubescens Ehrh.), Norway spruce (Picea abies (L.) Karst.) and European rowan (Sorbus aucuparia L.) were analysed in moderately and heavily damaged stands, in two types of windstorm-created microsites, i.e. root-plate pits and mounds of uprooted trees, and on intact soil at different stages since disturbance.

Regeneration was significantly taller in heavily damaged areas. Initially the mortality probability was indifferent to microsite type and increased later for regeneration on intact soil compared to that on the storm-induced microsites. For A. glutinosa and Betula, mortality increased with storm severity, whereas mortality of P. abies was initially low and became higher with time since disturbance, mainly in areas with increased amount of coarse woody debris. Eventually, height and height increment in previous years were clearly negatively related to mortality probability, and competition levels in previous years increased chance of death.

In northwestern Estonia, in sandy pine forests burned 2 or 22 years ago, we studied the effects of forest fire and postfire management on the successional changes in regeneration abundance, species composition and tree height. Five types of sample plots were established: (1) areas without fire damage, (2) burned uncleared areas, (3) burned areas cleared after forest fire, (4) burned uncleared areas with live trees, and (5) burned uncleared areas with dead trees. Three main tree species common to (hemi)boreal forests, that were found in sufficient number, were analyzed: birch (Betula pendula Roth., Betula pubescens Ehrh.), Scots pine (Pinus sylvestris L.), and European aspen (Populus tremula L.). Clearing burned areas after forest fire significantly reduced the abundance of regeneration compared with burned uncleared areas, but favored height growth of P. sylvestris in later development. Immediately after fire, Betula was more successful in regenerating. P. sylvestris and P. tremula were not regenerating immediately after fire, and after some time P. sylvestris started to dominate.

Effects of climate change on forest growth in Norway

Micky Allen
Norwegian Institute of Bioeconomy Research

Changes in climate patterns have been shown to have both positive and negative effects on the growth of boreal forests. An understanding and quantification of these effects will aid in policy making and management decisions. Using data from long term research trials of Norway spruce, established in stands planted between years 1920 to 1950 and covering almost six decades of measurements (1957-2016), changes in annual productivity in Norway were examined. Results indicated large increases in productivity beginning in the period between 1990 and 2000. After accounting for the effects of stand variables, such as age, site productivity, and stand density, on production, an analysis of climatic data indicated that the main drivers of the observed increased in production were extended growing seasons and increasing growing degree days (GDD). On the average, growing seasons increased by as much as 20% while the GDDs increased as much as 50%. An examination of maximum-size density relationships indicated that the self-thinning systems were not changing. However, increases in mortality rates suggest that forests are moving through the systems faster.

Simulated long-term effects on growth and economy of different strategies for precommercial thinning in Pinus sylvestris

Nils Fahlvik
SLU - Swedish University of Agricultural Sciences

The influence of the intensity and timing of precommercial thinning (PCT) on stand development and financial return were studied in Scots pine stands. Functions describing the early development of the stand structure after PCT were developed. The functions were based on 195 plots within 41 PCT experiments in Sweden. The dimension distribution of the established stand was estimated and used as input to the decision support system Heureka to simulate the stand development until final felling. The studied treatments included PCT to 1000, 2000 and 3000 stems ha-1 at mean heights of 2, 4 and 6 m. Stands with PCT to 1000 stems ha-1 were left without any further thinnings. Separate simulations were carried out for different site fertilities. Mean annual volume increment increased with increasing number of stems after PCT whereas the timing of PCT had only minor effect. The land expectation value generally decreased with increasing mean height at PCT, primarily because of increased cost for PCT. Land expectation value decreased with increasing number of stems after PCT at low site fertility whereas only minor differences were found for PCT to 1000 and 2000 stems ha-1 at medium and high site fertility. The general pattern persisted but the differences were less pronounced when the influence of PCT on future timber quality was taken into account.

Establishment and initial growth of planted Scots pine and Norway spruce on low and high fertility sites in northern and southern Sweden

Oscar Nilsson
SLU - Southern Swedish Forest Research Centre

Scots pine (Pinus sylvestris L.) and Norway spruce (Picea Abies L. Karst.) are the dominant tree species in Sweden. Even though the species have very different requirements, silvicultural measures applied at regeneration, such as site preparation methods, are often the same. To be able to choose proper regeneration methods and species at different sites, a study was established with these species where growth and survival was studied at four sites, one poor and one fertile site in northern respectively southern Sweden. The trials were established on forest land 2011 and 2012, just after harvest of the previous crop. In order to create environments with different nitrogen availability, three different soil treatments were applied, being: i) control, ii) bare mineral soil and iii) turned over soil. The soil treatment plots were then split in half, where a fungicide was applied once in one of the two sub-plots. The fungicide decreased growth in an approximately similar way for all soil treatments, species and sites, and the negative effect of fungicide was still present after 5 and 6 years. For Norway spruce, growth was significantly higher in the turned over soil treatment compared to the bare mineral soil treatment at all sites. Whereas, for Scots pine, the highest growth was found on the turned over soil treatment and the lowest growth on the control treatment. This indicates that Norway spruce is more negatively affected when all organic material, and hence part of the nitrogen pool is removed, in comparison with Scots pine, that seems to get a hold of nitrogen even on the bare mineral soil treatment. At the most fertile site in southern Sweden, no effects of either soil- or fungicide treatments could be found for Scots pine, indicating a high availability of nitrogen at that site. This study shows a more rapid initial growth of Scots pine overall, a time-lag of the positive effect of the turned over soil treatment on poor sites, and that growth of Norway spruce is more negatively affected in environments with less availability of nitrogen.

Pitfalls in stem growth measuring – Annual, seasonal and daily fluctuation in DBH of Scots pine, Norway spruce and Silver birch in the climatic circumstances of Finland

Pentti Niemistö,
Luke, Finland

Monitoring of daily and annual changes in tree diameters in Finland was performed 2009-2016 via automatic and manual girth bands on plots belonging to the European FutMon/ICP-Forest network. The aim of this study was to date and rate the growth of Norway spruce (20 automatic bands and 95 manual bands in seven stands), Scots pine (105 manual bands in seven stands), and birch (5 automatic bands and 20 manual bands in two stands). Another aspect of the research was identification of the real growth signals from the girth-band data, including also impacts of temperature, weather conditions, and diurnal rhythm with expansion during evening and night and with shrinkage during morning and day.

Seasonal chances in Scots pine DBH were surprising according to manual girth band measurements in 2-4 week intervals. The expansion of circumference continued after growing season to late autumn, and stayed on high level during winter before the shrinkage in spring. The respective phenomenon was slighter but able to measure also for Norway spruce, but not at all for birches. The result is harmful from the point of view of permanent plot measurements, because we have assumed DBH to be rather stable from August to May with flexible timing of measurements. Systematic error in DBH between early and late autumn can be even 1 mm that means 10 % mistake in the increment of 5-year period in our northern slowly growing trees.

According to automatic girth band measurements with one hour intervals during the growing season the measured increase – and occasional decrease – of stem circumference includes both the formation of new cells and changes in the water potential of the stem. On a rainy day, stem diameter suddenly increases as the water content of the stem grows but may decrease again as the water content then falls. These reversible changes in the stem diameter of Norway spruce were as great as 0.5 mm. The daily fluctuation in diameter of mature spruces was 0.2 mm. In silver birch, both these changes were smaller. Our findings of possible abrupt change in diameter caused by the freezing of stems during winter are still contradictory and more careful analyses are needed.

Consequences of increasing cuttings with the current level of silviculture

Saija Huuskonen 1), Kojola Soili, Salminen Hannu, Lehtonen Mika, Ahtikoski Anssi & Hynynen Jari
1) Natural Research Institute Finland (Luke)

The biomass production potential of forests has great importance in Finland. New investments in modern bioproduct mills by forest industry result in increasing demand for domestic wood. Recently, the total annual consumption of domestic wood and biomass has been approximately 65 million cubic meters. Since the 1970s, the annual increment of growing stock, being currently ca. 105 million cubic meters, has been greater than the drain. Thus, the timber production potential of Finnish forests is not fully in use. At the same time, forest owners' activities to implement forest management practices lag behind the level recommended by silvicultural guidelines. For instance, the total area of precommercial thinnings has been only about half of the estimated need. We studied the impacts of increasing harvesting activity on future wood production and harvesting potential assuming that the volume of silvicultural treatments remains at the current level. The 11th National Forest Inventory data (ca. 46 000 plots, covering the total area of commercial forests) and Motti-software were used to calculate two wood-production scenarios for the next 100 years: 1) "Business as usual" (BAU), where the utilization of commercial forests and the level of silviculture remained at the current level, and 2) BAU80, where annual cuttings were increased up to 80 million cubic meters although the level of silviculture remained. The poster will present the impacts of increasing harvesting activity on growing stock, removals, and annual areas of forest management practices.

Downy birch management on drained peatlands – From useless thickets to valuable resource?

Soili Kojola 1), Niemistö Pentti, Ahtikoski Anssi & Laiho Raija

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Downy birch stands on drained peatlands are often considered useless because they typically do not yield good-quality sawn timber. In Finland, downy-birch stands (ca. 0.5 million hectares) have potential for pulpwood and/or energy-wood production, however. We examined financial performance of alternative management regimes (with or without thinnings, different thinning intensities, several rotation lengths) combined with alternative harvesting methods (pulpwood, energy wood, or integrated, energy wood being delimbed stems or whole trees). We used data from 19 experimental stands monitored for 20–30 years, and assessed profitability as combination of net present value of the birch generation and bare land value of future generations of Norway spruce. According to results, thinnings were generally unprofitable, especially when aiming to produce energy wood, whereas aiming for pulpwood, light precommercial thinning was competitive. The best stand age for final cutting was 40–65 years – earlier for very dense stands and energy-wood harvesting with advanced machinery, later for precommercially thinned stands and pulpwood harvesting.

Biological legacies in forests of Western taiga habitat type

Teele Paluots 1) and Henn Korjus 1)

1) Estonian University of Life Sciences, Tartu, Estonia

Lahemaa National Park was established in 1971, being the first national park in Estonia. It`s representing and protecting the nature and cultural heritage, typical and unique to North Estonia.It is also one of the most important forest conservation areas in Europe and included to Natura 2000 network.

There was a large scale forest inventory covering 60% of Lahemaa National Park forests over 20 000 hectares during 2009-2011. The inventory involved all national park management zones (nature reserve, special management zone, limited management zone) and consisted of forest survey and revaluation of Natura 2000 forest habitats. We used Western taiga habitat type data to evaluate the occurrence of biological legacies in these areas. Deadwood occurrence by habitat representativeness is higher older forest classes, but the deadwood was not substantially present on 32% of area in old-growth forest class. This indicates that these areas don`t have potential of biological legacies to provide critical niche habitats for different species.

We also compared deadwood data from Estonian Network of Forest Research Plots (ENFRP) located in Lahemaa National Park with other pine dominated forests by literature. As a result we saw that older stands had less snags than younger ones. This can be result of competition and natural succession, because in older stand these snags have been already fallen down. The lower number of snags can also indicate previous management in ENFRP plots.

Keywords:
Forest habitat types, Habitat quality Large scale forest inventory NATURA 2000 network Deadwood

Height-diameter functions for naturally regenerated broadleaved stands in Estonia

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The area with naturally regenerated broadleaved tree species has been increasing in Estonia over the last couple decades. Mainly birch, but also other broadleaved trees dominate on such areas. Therefore, there is increasing need for models that could reliably describe the development of naturally regenerated birch stands. Empirical height-diameter functions, are commonly used to describe the allometric development patterns along the rotation period. Because tree height measurements are more time consuming and costly, commonly height is measured on a subset of trees and predicted for the rest of the trees in the sand using height-diameter functions. Most of the height-diameter functions, currently used in Estonia has been developed in the middle of last century, when different climatic conditions prevailed. Besides that, most of such models are developed for mature stands and mainly for coniferous tree species. Growth modelling in young stands in Estonia is based on stand density and species based average stand height, however such models fail to describe height variability in young stands.

The aim of our study is to develop generalized height-diameter functions, for naturally regenerated broadleaved stands in Estonia, covering different stand development stages. The data for height-diameter calibration has been collected from network of permanent sample plots that include broadleaved stands of different age. By combining data from different stand development stages, we have developed height-diameter curves for different broadleaved tree species.

OUTDOOR PRESENTATIONS:

Carbon exchange measurements at a flux tower in Hurdal

Holger Lange,
Dep. Terrestrial Ecology, Norwegian Institute of Bioeconomy Research

The meteorological tower at Hurdal, close to the Level II ICP-Forests plot, is operated by the Norwegian Institute for Air Research (Nilu) since 1996. A standard set of meteorological variables is monitored at high frequency. Since 2017, the tower is also a terrestrial ecosystem station of the Integrated Carbon Observation System (ICOS) network. ICOS (https://www.icos-ri.eu/) is a European Research Infrastructure targeting carbon exchange measurements between the atmosphere, vegetation on land, and the ocean. ICOS stations utilize the Eddy Covariance (EC) technology to quantify the uptake and release of carbon within the footprint of the tower. The talk provides a short introduction into ICOS and its goals, the measurement equipment needed, and the requirements to be fulfilled for a station to qualify as an ICOS site. Test measurements on top of the Hurdal tower will be performed this year, whereas routine measurements commence with the beginning of 2018.

Variation of Norway spruce growth within a season and correlations with climate

Kjell Andreassen 1) , Volkmar Timmermann 1), and Wenche Aas 2)

1) Norwegian Institute of Bioeconomy Research

2) Norwegian Institute for Air Research

The level 2 forest monitoring site was established in 1996 in a Norway spruce stand. The inner plot is 0.1 ha, the volume is 488 m3/ha, mean diameter is 28 cm, mean height is 26 m, density is 630 stems/ha, age at breast height is 90 years, the increment is 17 m3/ha/yr. The mean diameter increment is 2.2 mm per year.

In this study we measured the growth with girth bands at breast height at 70 trees every two week in the growth season. The trees were measured from the last half of April to the first half of October. Daily measurements of climatic variables from a 30 m high monitoring tower 20 meters from the plot at two heights, 2.5 and 25 m, were used. In addition tree characteristics including diameter, height and crown length were also tested in estimating tree growth.

In this analysis we correlated the periods of Norway spruce diameter increment (ID) with climatic data. The results show that diameter growth at breast height starts in beginning of May and have a peak in the last part of June. The growth decrease during July, August and September and in October almost no increment is observed. In this kind of measurements residuals due to daily shrinkage and swelling caused by fluctuations in temperature and humidity disturb the growth measurements. Such shrinkage and swelling is not associated with formation of new cells which is the normal tree diameter growth we want to measure. However, by having two week growth periods we only measure the mean growth over this period and fluctuations from day to day are mainly eliminated – e.g. the mean of two week temperature. Since we have many growth periods over several years this kind of residuals have less influence. We cannot totally eliminate these residuals which reduce the explanation coefficient. In addition, small disturbances from animals and wind blow can also influence the girth band where a scale of 1/100 of a millimetre is assessed in a complicated reading of a nonius (vernier) scale.

In this study, data from only the growth season were used. We concluded that 13 % of the growth could be explained by climatic variables, while 7 % could be explained by tree variables at this plot.

Development and growth in a mixed Norway spruce and Scots pine site

Micky Allen, Kjell Andreassen and Stig Støtvig
Norwegian Institute of Bioeconomy Research

The site was established in 1920 in a forest owned by the church in Hurdal municipality situated at 60° N and 11° E 40 km north of Oslo airport. The altitude is 275 m above sea level, and the soil is moraine formed and developed by glaciers. The mean temperature is 4°C and the precipitation is 845 mm/yr.

The site is a conifer mixture of Norway spruce and Scots pine, and there are two plots with different treatments. In plot 30 there were several years between heavy thinnings (1935, 1960, and 1978). In plot 31 there were more frequent and small thinnings in the beginning with 5 year intervals. In the last half of the period there were less frequent thinnings in plot 31. In plot 30 there was a high proportion of Norway spruce the first 35 years, and in plot 31 there were a small proportion of spruce the first 70 years. Scots pine is the major tree species the whole period in plot 31. In plot 30 pine is dominating only the last 50 years. In both plots all of the medium and large Norway spruce trees was harvested in the 1960's and 1970's and made room for a new regeneration of spruce that could grow up below large Scots pine trees.

The result of these two different treatments is two stands with more or less similar standing volumes and proportions. In both plots large Scots pine is dominating the stand with mean heights of about 30 m and mean diameters of about 50 cm. The gross volume production during the last 84 years including cuttings, mortality and increased volume is 708 m3/ha in plot 30 and 604 in plot 31. However, a larger volume production of Norway spruce is observed in plot 30, and a larger proportion of Scots pine is observed in plot 31. This observation indicates a larger growth in mixed stands with a higher proportion of Norway spruce.

The stand age is very high with about 185 years for the pine trees in both plots. The vitality of the trees is good considering the high age. In Norway, these plots are among the oldest plots which are followed by frequent measurements in almost 100 years since 1920. These old plots are important to follow with additional measurements and broadening the time series of forest growth and yield data in a time with changing climate and concerns for the development of native tree species.

Chemical elements in canopy throughfall and soil water

Nicholas Clarke
Norwegian Institute of Bioeconomy Research

Chemical components in throughfall and soil solution have been monitored at Hurdal from the mid-1990s. Mean deposition of inorganic nitrogen in throughfall from 1997 to 2015 has been about 24 meq/m2 without any clear trend. In the same period, mean non-marine sulphate deposition has been about 13 meq/m2, with a generally decreasing trend especially in the first years of monitoring. These trends are similar to trends elsewhere in Europe. There is of course considerable interannual variation in deposition amounts, caused largely by variation in precipitation. Non-marine sulphate concentrations in soil solution at 15 cm depth have also shown a decreasing trend, reflecting the trend in throughfall. Total aluminum concentrations at the same depth have fluctuated, but have also shown a largely decreasing trend. Aluminum concentrations are normally under levels considered to be toxic to plants; in addition, much aluminum appears to be organically bound and therefore relatively non-toxic. The soil solution pH at 15 cm depth rose in the first decade of monitoring from 4.5 in 1997 to 5.3 in 2006 and then declined to 4.4 in 2015. The reason for these changes is unknown, but appears to be due to site-specific factors as a similar pattern is not observed at other monitoring sites.

Transformation of recent forest on abandoned agricultural land for the benefit of biodiversity, ecosystem services and green solutions – TRANSFOREST

Per Kristian Rørstad 1) and Bjørn Nordén,
1) Norwegian University of Life Sciences

General information about the project
Regrowth of forests on abandoned agricultural land is a highly topical theme for rural land use, because of changed land use practices, due to e.g. new technology, low profitability in agriculture and centralization processes, and accelerated by climate change. The regrowth may lead to loss of ecosystem services provision from pastures, fields and ecotones, but if carefully managed may enable some of these services while also providing possibilities for sustainable use and restoration.

The encroaching, young, often mixed, forests may be restored to semi-open temperate deciduous forest, a habitat subject to multiple pressures: introduced pathogens, spruce succession, excessive browsing by deer etc., but of exceptional value for biodiversity and could be an extremely valuable supplement to existent climate forest management. There is a need for economically and socially acceptable solutions, and farm economic, societal, policy, and climate effects and aspects will be carefully evaluated. We will test if the managed areas may contribute to the expansion and increased connectivity of semi-open temperate deciduous forest, and to smart green solutions for biodiversity, ecosystem services including recreational and local community aspects, value for recreation and rural livelihoods.

Information about the Kolås experimental plot and the experimental design in general
The plots are located within Kolås Nature Reserve (established in 1982 and extended in 2014). The purpose of the conservation is to preserve an area that contains endangered, rare and vulnerable nature types that is of particular importance to biological diversity. The reserve is dominated by rich broadleaves – although the experimental plots are dominated by spruce. The variation from rich marsh forests to more sun exposed forest types on dry soils gives a high diversity in habitats and species diversity. According to the County Governor, parts of the experimental plots may have been tilled agricultural land and pasture.

The project has 13 experimental plots in South Eastern Norway and a corresponding number in Sweden. At each location two 100 by 100 meters plots are established: control and treatment. In the treatment plots about one third of the basal area is thinned. There is a large variation between the locations with respect to nature type, succession stage, tree density and conditions for forest operations.

We study the short-term effects (after 2-3 years; 2018 and 2019) of restoration thinning on biodiversity at these 13 + 13 sites, and the studied organism groups are vascular plants, hoverflies, wood-decaying fungi, Homoptera and lichens on ash (Norway sites only). In addition, we study the effects on ash dieback and oak powdery mildew.

Long-term effects (after 16 years; 2018) on regrowth inside and outside grazing exclosures are studied at 13 additional sites with a similar treatment in 2001/2012 in Sweden, belonging to the Swedish Oak project.

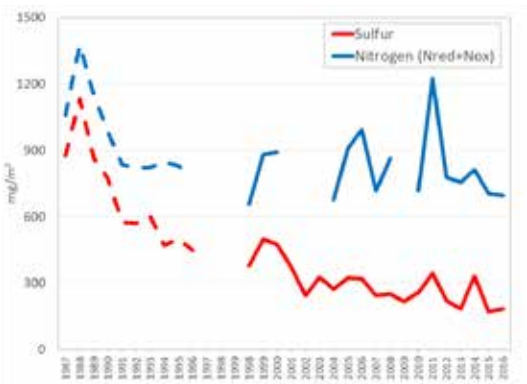
Some results of the pre-treatment surveys, and expected results will be presented in the field.

Monitoring of long range transboundary air pollution. The measurements at Hurdal in an international perspective

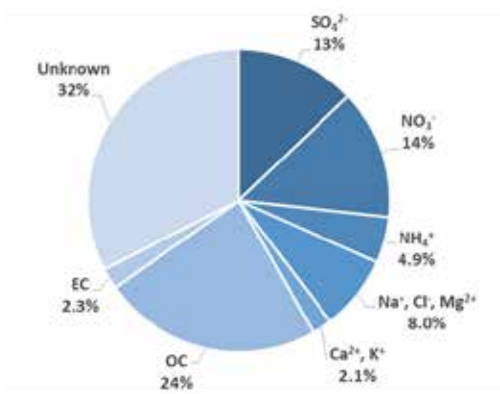
Wenche Aas
Norwegian Institute for Air Research

The atmospheric monitoring program at Hurdal is part of the Norwegian monitoring of long-range transported air pollutants and supports the European Monitoring and Evaluation Program (EMEP) under the Convention on Long-range Transboundary Air Pollution (CLRTAP), to address impacts of air pollution on ecosystems, human health, materials and climate change. It includes hourly measurements of tropospheric ozone and meteorology, daily measurements of particulate and gaseous inorganic compounds in air and precipitation, weekly measurements of particulate matter and elemental- and organic carbon (EC/OC), and weekly measurements of heavy metals (Cd, Pb, Zn) in precipitation. The highest level of air pollution is seen when long rang transport occur from the European continent, except for NO2 which is from the relatively high traffic emissions in this region. Hurdal has been in operation since 1998, though trend analysis back to 1987 is possible when combining with the earlier site at nearby Nordmoen. For most components, there has been significant reduction in concentration and deposition level, i.e. a reduction of almost 80% in sulfate in 30% in nitrate, though no significant trend in ammonium since 1990. The aerosol mass consists of about 25% organic carbon and 30% secondary inorganic aerosols from various origin.

Trends in total deposition (wet + dry)



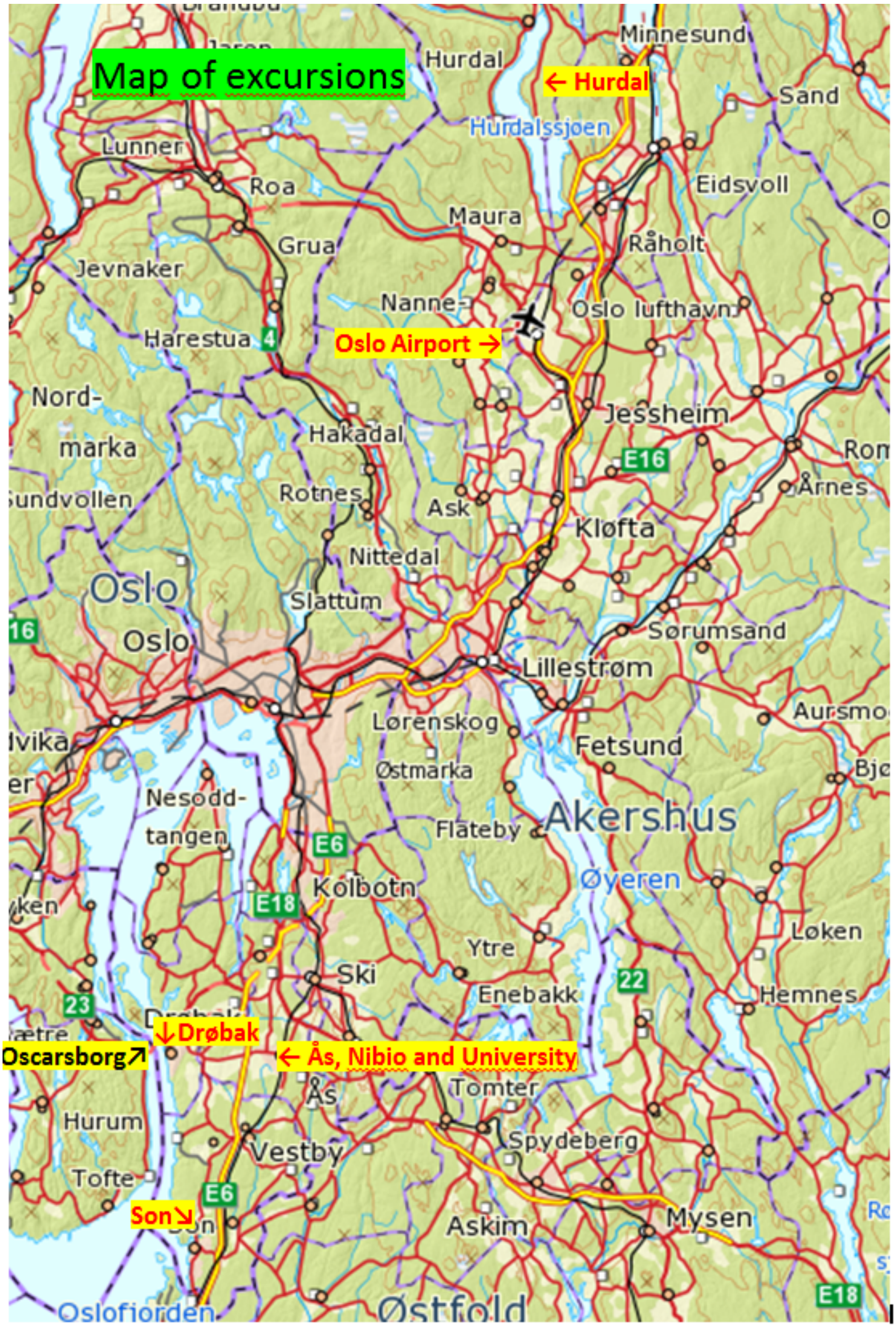
Composition of PM10 in 2016



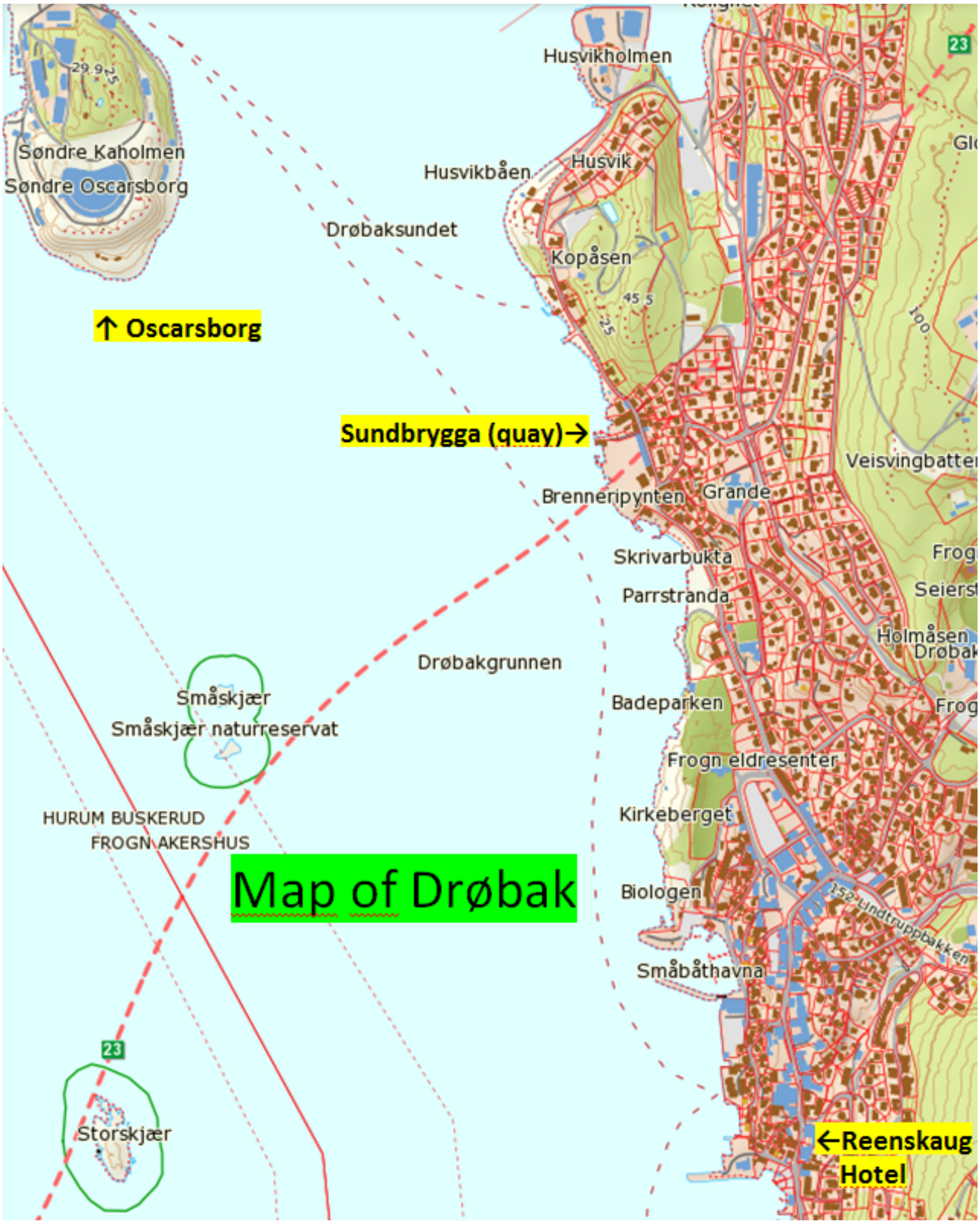
INDOOR PRESENTATIONS:

Time	Author
Wednesday 14. June	
08.00-08.10	Kjell / Kjersti /Andreas
08.10-08.20	Arne Bardalen (Director of Research, NIBIO): Opening of conference
08.20-08.40	Karri Uotila
08.40-09.00	Kristi Parro, Marek Metslaid, et al
09.00-09.20	Oscar Nilsson
09.20-09.40	Kjersti Holt Hanssen and Harald Kvaalen
09.40-10.00	Discussion and Coffee
10.00-10.20	Jari Hynynen, Hannu Salminen & Harri Mäkinen
10.20-10.40	Hannu Salminen & Jari Hynynen
10.40-11.00	Pentti Niemistö
11.00-11.20	Nils Fahlvik
11.20-11.40	Harald H Kvaalen, Aksel Granhus & Gunnhild Søgaard
12.00-12.50	Lunch
13.00→	Excursion to Son, Conference dinner
Thuesday 15. June	
08.00-08.20	Eneli Allikmäe, Diana Laarmann, Henn Korjus
08.20-08.40	Teele Paluots and Henn Korjus
08.40-09.00	Vivika Kängsepp
09.00-09.20	Clara Antón Fernández & Rasmus Astrup
09.20-	*Coffee and Poster presentations*
	Soili Kojola, Niemistö Pentti, Ahtikoski Anssi & Laiho Raija
-09.40	Saija Huuskonen, Kojola, Salminen, Lehtonen, Ahtikoski & Hynynen
09.50-10.10	Aleksei Potapov and Hordo, M.
10.10-10.30	Micky Allan
10.30-10.50	Kjell Andreassen and Ole Einar Tveito
10.50-11.50	Business meeting. Applications. Discussion. Closing remarks. Next meeting.
12.00-13.00	Lunch

Map of Excursions



Map of Drøbak



NIBIO
NORSK INSTITUTT FOR
BIOØKONOMI

Norsk institutt for bioøkonomi (NIBIO) ble opprettet 1. juli 2015 som en fusjon av Bioforsk, Norsk institutt for landbruksøkonomisk forskning (NILF) og Norsk institutt for skog og landskap.

Bioøkonomi baserer seg på utnyttelse og forvaltning av biologiske ressurser fra jord og hav, fremfor en fossil økonomi som er basert på kull, olje og gass. NIBIO skal være nasjonalt ledende for utvikling av kunnskap om bioøkonomi.

Gjennom forskning og kunnskapsproduksjon skal instituttet bidra til matsikkerhet, bærekraftig ressursforvaltning, innovasjon og verdiskaping innenfor verdikjedene for mat, skog og andre biobaserte næringer. Instituttet skal levere forskning, forvaltningsstøtte og kunnskap til anvendelse i nasjonal beredskap, forvaltning, næringsliv og samfunnet for øvrig.

NIBIO er eid av Landbruks- og matdepartementet som et forvaltningsorgan med særskilte fullmakter og eget styre. Hovedkontoret er på Ås. Instituttet har flere regionale enheter og et avdelingskontor i Oslo.