Adaptation of trees and stands to forest disturbances: management considerations

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Hurricanes and Fire: Interacting disturbances in coastal forests of the southeastern United States

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Hurricanes are a constant threat to the coastal areas of the southeastern United States and represent a major source of wind-related disturbance to the forests of the region. Many of these forest ecosystems can be characterized as fire adapted with a fire regime dominated by frequent low intensity fires. Wind damage from hurricanes can dramatically alter the amount of available fuel for subsequent wildland fires and this additional fuel load often increases the intensity of the fires. A number of modeling tools are used to investigate the interaction of these disturbances. Wind damage is assessed using a parametric hurricane model to generate wind fields which are coupled with the GALES model to assess forest stand damage. The wind damage is subsequently converted to coarse woody debris for inclusion in a fire risk assessment tool (Southern Wildland Fire Risk Assessment). This chain of modeling tools is used to investigate the impact of Hurricane Katrina. The counter-intuitive result is fire risk is lower following a hurricane; a possible mechanism is the addition of large fuels acts as a heat sink, reducing flammability. Suggestions for further research are explored.

Survival of Scots pine after wildfires depending on damage degree

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During last 2 decades in Latvia forest fires affected in average 1000 ha per year. Most of those fires are in pine forests. Forest managers have to take decision about future management activities in these areas to optimize economical and ecological as well as social considerations. Therefore it is important to predict survival probabilities of trees after such events and research was financed by JSC "Latvijas valsts meži".

During 2003 to 2009 totally were established 168 sample plots (500 m^2) within 28 different fire events, which covered wide range of age groups (20 to 180 years) and forest site types (from dry mineral soils to wet peat soils and drained soils). For each tree (N=3237) was measured DBH, calculated height as well was assessed fire effects (height of bark char, crown scorch, root char) and presence of damage by stem boring insects. Survival as well as presence of stem boring insects was assessed during 2008 to 2009 twice a year.

For survival assessment we used Life tables and Cox regression analysis (SPSS14).
Survival depends on tree diameter and time since fire. Smaller trees (dbh<14cm) has almost 3 times higher hazard rate than trees of dbh>30cm with similar damage rate. 36 month after forest fire survival probability is higher than 80% for pines with dbh from 6 to 14 cm and max height of bark char less than 1m and no root damage, while pines with dbh of 14 to 22 cm have the same survival probability if max height of bark char does not exceed 3m. Larger trees have survival probability more than 80% if bark char does not exceed 3 m or if no more than ¼ of roots is exposed and max bark char does not exceed 2 m.

Chemical and biological renaturalization of afforested and abandoned arable *Arenosols*

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Comparative study on chemical and biological renaturalization of arable *Arenosols* were performed in 45-year-old Scots pine plantations and arable land abandoned for 11 years. It was determined that former ploughing Ap horizon was renaturalized according to the pH and the concentrations of organic C, total N and Al^{3+} ions in pine plantations. The renaturalization of organic C and both total and mineral N concentrations was found in abandoned arable land as well. The renaturalization of ground vegetation (forest type – *Vaccinio-myrtillosa*) in pine plantation were explained by the accumulation of organic layer. The changes in species diversity of ground vegetation reflect the leaching, mainly mineral N, in abandoned formerly fertilized arable land. In mineral topsoil of *Arenosols* the abundance of the microorganisms (soil bacteria prevailed) was in average by 2-5 folds higher in abandoned land than in pine plantations. The microorganisms in abandoned arable land showed the homology to the actinobacterias and proteobacterias, while soil microorganisms in pine plantations were presented only by proteobacterias.

Key words: *Arenosols,* afforested or abandoned arable land, chemical parameters, ground vegetation, soil microorganisms

Influence of shelter wood cuttings in pine stands on undergrowth and ground vegetation development

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Nowadays is important to reduce impact or forest management. One measure is replacing clear cutting to by shelter wood cuttings. The aim of this study was evaluate the succession of undergrowth ground vegetation, herbs and moss after shelter wood cuttings in hemiboreal pine forests. Investigations were conducted in mature stands after shelter wood cuttings of different time in Eastern part of Lithuania. We recorded projection cover of herds and mosses in percent in 100 m^2 (10x10m) plots and amount of saplings in transect of 20 m length and 1 m width. The highest number of pine seedlings was recorded in shelter wood cuttings in second year after cutting and number of seedling decreased in older shelter wood cuttings. It was determined that average number of species did not change in the shelter wood cutting of different age. The overall average projection cover of herb layer increased after shelter wood cuttings. Average projection cover of *Vaccinium myrtillus* and *V. vitis-idaea* decreased, while average projection cover of *Calamagrostis arundinacea* increased. Average projection cover of mosses decreased after shelter wood cuttings.

Effects of windthrow disturbance on forest - a northern perspective

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Wind continuously affects the structure and functioning of forest ecosystems. It generates a mosaic of heterogeneous habitat patches at various spatial scales, thereby maintaining biodiversity. In managed forests, wind-induced damage is a continuous cause of economic loss. E.g. in Finland, two storms in November 2001 blew down 7,3 Mm^3 of timber in southern and western parts of the country. Economical loss by wind damage in managed forests is due to reduction in the yield of recoverable timber and value of harvested timber and increased costs of harvesting. Furthermore, broken and uprooted trees left in the forest can lead to detrimental insect attacks on the remaining trees. In Finland, the strongest winds usually occur from autumn to early spring. During winter months, frozen soil increases tree anchorage and decreases vulnerability to uprooting. The risk of wind damage is expected to increase in the future, if the period of unfrozen soil is increasing due to climate warming. Frost simulations have shown that the duration of soil frost will decrease by two months in southern Finland and by one month in northern Finland given a temperature increase of 4 °C. Since occurrence of strong winds during unfrozen conditions increases risk of uprooting, consideration of the wind damage risk will be an important task for forest managers in the future.

Key words: windthrow; managed forest; uprooting; Finland; climate change

Climate change effect on the plant-herbivore interaction: trends and patterns

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Climate change and its abnormalities are a serious global problem affecting species survival and ecosystem integrity. Climate change is likely to affect forest biotic communities and their interaction. Climatic factors were and are one of the essential limiting factors for wildlife at all times. However, the certain factors or their permutation have the different limiting importance of for the certain animal species, age class or sex in the different seasons. Increased changeability and the number of extreme events cause changes in the distribution, foraging, population parameters of animals and their impact on the environment. Herbivore population parameters and their impact on forests have been studied in the context of climate changes: a) in all country using the official statistics and b) in the different natural and climatic regions within the herbivore-plant monitoring network.

Closeness of animal population parameters to the optimum indicates conditions favourable to the realization of reproductive potential of roe deer and red deer. Warming is disadvantageous for moose because of its sensibility to the thermal stress causing compulsive gathering in habitats of the favourable thermal regime and the local increase in the impact to forest. Under warming conditions, there are the negative close links between the consumption of shoots of woody vegetation and the average temperatures in the non-vegetative period while an increase in the number of moose and red deer negatively affects woody vegetation. The further warming is a presumption of the increase in damaged area. However, the weather changeability suppresses the increase in animal number.

Key words: forest, herbivores, climate change, natural disturbance, damage, regions

Responding to an uncertain future by forest tree breeding

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Natural populations of forest trees have gone through a number of rapid climate changes during their evolution history and a body of evidence suggests that they have mechanisms and capacity to also respond to the upcoming predicted global warming. However, the local adaptation of long-lived forest trees is a fairly slow process which is likely to lag behind a rapid change in the environment due to the lack of free spots available for colonization by more adapted genotypes. Artificial regeneration using forest reproductive material developed by means of tree breeding can potentially accelerate adaptation to a changing environment. Tree breeding programs apply basically the same set of mechanisms as natural evolution to improve the adaptedness of trees to the environment among other economically important traits. The maintenance of large genetic variability in breeding populations is a prerequisite for developing novel genotypes more adapted to changing conditions. Another important feature of long-term tree breeding programs is the genetic testing of breeding materials in multiple designed field trials which are representative of a range of light and temperature regimes and edaphic site conditions. Multi-environment experiments provide valuable information on the reaction norms of genotypes which may be used to detect those genotypes that are characterised by a stable performance over a range of varying environment and sufficient plasticity to meet climate fluctuations. The genetic base of the breeding programs may also be expanded by samples from (southern) populations presumably more fit to future climate, to undergo the same testing procedures as local breeding materials. The breeding cycle in forest trees, including testing, one or more selection phases and crossing, is commonly 20-25 years. From an evolutionary viewpoint, genetic changes needed for adaptation may be accomplished and transferred to forestry at much faster intervals in breeding populations (through man-made evolution) than in forest stands exposed to natural selection.

Adapting Swedish tree breeding and deployment strategies to climatic change

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Changes in climatic conditions as well as changes in human utilisation of forests and forest products generate new requisites for reforestation material. This situation could be handled with breeding, giving options to meet an unpredictable future. The Swedish tree breeding programs are designed to include long term changing conditions through breeding population structuring, long-term breeding objectives, and testing techniques with extended environments. Putting higher weight on selection criteria like small genotype x environment interaction and superior vitality/resistance, will yield material with increased phenotypic stability and robustness in a changing climate. However, breeding is time consuming and it will take time before actions taken in the breeding populations will affect propagation populations and operative reforestations.

A flexible deployment strategy based on response functions can match reforestation material with growth environment at a given site at a given time period. And a change in deployment strategy can be applied already today. Outcomes from Skogforsk's tree-breeding work has provided information on where the various seed sources (seed orchards and provenances) should be used to get highest return in production and value. Now, this strategy is under adjustment, because the climate is already warmer than when the recommendations were made. Briefly, we are taking into account both the present conditions, which is crucial for seedling survival and establishment, and future conditions, which determines the growing conditions during the rotation time. The proposed change is quite small – seed sources should be used about half a degree of latitude further north than before, or at about fifty meter higher altitude. Still, this will increase the volume production per hectare by some percentage. The recommendations will be continuously updated in accordance with the climatic change. Further, new response/transfer functions are under development in cooperation with climate researchers. The aim is to explain tree performance with variables used in climatic research, enabling prediction of tree performance in various environments both in present and future climate.

Utilizing "new" tree species in Sweden, such as Sitka spruce, Douglas fir and poplar is another way to adapt to climate change.

Keywords: Forest tree breeding; adaptation; deployment; climate change.

Effect of increased temperatures and carbon dioxide on the annual rhythm of young Scots pines

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We analyzed how the forecasted increase in summer temperatures together with increased carbon dioxide levels will likely affect the hardening, dormancy and dehardening development of young Scots pines (*Pinus sylvestris*) seedlings from Finland and also from other more southern countries.

Seedlings were grown for one growing season under the prevailing summer conditions for the year 2009 (control, outside in nursery, 1261 d.d.) and in greenhouse conditions under the forecasted future summer temperature conditions in southern Finland for the years 2030 (1600 d.d.) and 2100 (2300 d.d.). In the greenhouses, two alternative irrigation treatments (wet and dry) were used. In addition the year 2100 condition was either with or without extra carbon dioxide (700 ppm). In the dormancy experiment seedlings were taken from deep dormancy conditions to the greenhouse where the temperature was raised +5 to +15°C compared to outside temperatures. The characteristics analyzed were i). visible terminal bud formation ii). bud burst iii). needle injuries and iv). and mortality, the latter two were based on artificial freeze tests.

Results showed that growth conditions during the previous summer has a major effect especially on hardening and dehardening development, bud formation and bud burst and a lesser effect on the dormancy breakdown.

During the hardening development needle injury as well as mortality levels and number of seedlings with visible terminal buds were significantly higher under the temperature conditions for year 2100 than under the temperature conditions for the year 2030 or under the local, natural growing conditions. Mortality and mean needle injuries were also, on average, significantly higher for dry than wet growing conditions. However, the lowest injury and highest survival levels was when the temperature during the previous summer was high together with high carbon dioxide levels.

It took 7-9 week high temperature treatment to cause some needle injuries during winter. Seedlings grown in year 2100 growth conditions for the previous summer had considerably higher injury levels than seedlings from the year 2030 conditions or seedlings grown with extra carbon dioxide.

Higher temperatures and low moisture together with northern origin tends to slow dehardening development, although the differences were smaller than during hardening development. Timing of bud burst did not follow that development predicted according needle injuries. Also during hardening development seedlings with visible terminal buds seems to have higher injury levels than corresponding material without visible terminal buds.

According our results, the summer conditions, temperature, moisture and CO_2 had a significant effect not only on the hardening, but also on dormancy and dehardening development of one-year-old Scots pine seedlings. It also seems to be evident that high summer temperature together with dry moisture condition slow hardening development, but high CO_2 concentration acts reverse this; thus the preliminary conclusion is that warming climate in northern hemisphere has considerable effects on to the yearly cycle of young Scots pines, but the risks of low survival and heavy injuries seems to very small at least with local seed material depending, however, on what is balance between precipitation and evaporation in future conditions.

Environmental and genetic effects on lammas growth of Norway spruce

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Observations done by foresters in Norway suggest that second flushing in the early autumn (lammas shoot) may have become more common in Norway spruce during the last decade. Lammas may cause subsequent forking of the leader shoot and thereby severe deterioration of the stem quality. With the support of the forestry authorities in the five counties around the Oslofjord a survey of lammas shoot formation and forking was carried out in the summer 2010. Twenty randomly selected trees at all permanent sample plots of the National forest inventory in cutting class II and below 200 above sea level were assed by trained observers. The most important results are that lammas formation increase strongly with increasing site index. At two of fifty eight sample plots (ca 3% of the area in this cutting class and region, more than 80 percent of the trees had lammas shoots. The likelihood of forking was much higher among trees that had lammas shoot the presiding year, suggesting that lammas shoots are a direct cause of forking. This could possibly be due to the combined effect of poorly developed hardiness in the bud formed after lammas formation. Alternatively the poorly developed bud after the second flushing may flush earlier the next spring and is then more likely to be damaged by late spring frost. The negative effects of forking on stem quality and the fact that the problem is most frequent at the best sites suggest that the future losses of value can become quite large.

Climate effects on the phenology of natural Norway spruce provenances

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Norway spruce (Picea abies) is one of the most intensively studied forest trees in Europe. Of particular importance for the adaptation to a boreal climate is the phenology of apical meristems; the synchronisation with temperatures in the spring and daylength in late summer. Spruce therefore shows strong clinal variation from south to north and from low elevations to high elevations in budflush, growth cessation and frost hardiness. The phenology is highly heritable but studies the last two decades also show that it is influenced by the temperatures during flowering and seed maturation. This is now explained as epigenetic effects; a "memory" of the climate the year the seed was developed. This memory probably last through the lifespan of the trees.

Summer and particularly autumn in 2006 was particularly warm in Mid-Norway. Seed harvested from natural stands that year were heavier and showed better germination than the seed nurseries have been sawing from the "big seed year" in 1970 and in the 1990s. However, the nurseries were surprised that the seedlings from the new seed grew taller and became frost hardy later in spring. They therefore requested a study to characterise the penology of the 2006-seed compared to the seed they were used to from 1970 and the 1990s.

We have so far been studying the budset of 1-year old seedlings, and budflush and growth cessation of 2-year old seedlings. The results show that plants from seed harvested in 2006 both have a delayed budflush in the spring and growth cessation in fall compared to seed from the cooler years. They behave as a more "lower-lying" or "southern" provenance adapted to a warmer climate. The degree of change seems to represent a transfer of 300-400 m in elevation. We do not believe that strong genetic selection in these forty years can make changes at this magnitude. We rather believe that the epigenetic effects play a major role in the natural adaptation to climatic changes on short term. The phenology and adaptation of a *provenance* is not static but dynamic and influenced by the prevailing climate change. The results confirm the annual variation we have seen in the phenology of seed orchard seed lately.

Growth and growth rhythm in pine and spruce

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Growth, defined as the rate and duration of cell proliferation in apical meristems, was studied in a pilot study with selected clones of Scots pine and Norway spruce to elucidate how breeding affects "growth". Growth on a cellular basis involves division, expansion and differentiation of cells. Cell divisions occur in the mitosis phase (M) of the cell cycle. One of the earliest ways of studying cell proliferation in plants is the mitotic index (MI). The relationship between MI and cell cycling or height growth is not straightforward, but MI does appear to be useful in assessing the timing of growth cessation. The proliferative capacity, potential doubling time (T_{POT}), can be estimated from cell cycle parameters.

By using DNA flow cytometry (FCM) cells in all phases of the cell cycle can be quantified. FCM quantifies the amount of fluorochrome bound to DNA by measuring the intensity of emitted light. In a one parameter FCM analysis using propidium iodide (PI) it is possible to estimate the fraction of proliferating cells, similar to the MI. In a two parameter FCM analysis with PI and Bromodeoxyuridine (BrdU), it is possible to determine growth kinetics from a single sample. In the analysis the thymidine analogue BrdU is incorporated during DNA synthesis and nuclei with incorporated BrdU can be detected using antibodies with the fluorochrome FITC. The DNA content and labelled nuclei with incorporated BrdU in different phases of the cell cycle are quantified simultaneously to derive the parameters needed to estimate T_{POT}.

13 clones of pine and 15 clones of spruce were studied. The clones were "plus-trees" selected in natural stands. Breeding values for height and survival had previously been evaluated after 9–11 and 11–18 years in the field. The clones were grafted to two clonal archives at Sävar (63°54'N) in Sweden. At each sampling, embryonic shoots from apical buds were incubated in BrdU for 12-16 hours at room temperature. Cell suspensions were made by mechanical homogenisation, filtering and fixation in methanol at -20°C. Analysis of DNA content and incorporated BrdU content was performed using FCM after treatment with antibodies and fluorochromes. The cell cycle parameters to estimate T_{POT} were derived after FCM-analysis. In samples collected in October a G2+M-index (c. MI) was constructed as the fraction of nuclei with double DNA content of all nuclei.

In summer the minimum values of T_{POT} for spruce and pine were approximately 30 h and 40 h, respectively. The increase in T_{POT} during late summer started earlier in spruce than in pine. For both species, the breeding values for tree height were negatively correlated with T_{POT}. In spruce, the breeding values for tree height were positively correlated with the G2+M index in October whereas they were negatively correlated in pine. Taken together, the results for spruce and pine indicate that selection for tree height primarily affects the timing of growth cessation, and secondarily the rate of cell proliferation.

Stand attributes and location define wind and snow damage in conifer mountain forests in the Eastern Pyrenees

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Stand-level models have been created that describe damage severity for three Catalonian pine mountain forests that follow an altitudinal range (*Pinus nigra* Arn. *salzmanii*, *Pinus sylvestris* L. and *Pinus uncinata* Ram.). The models are based on national forest inventory databases and include variables related to the spatial location and structure of the stands. Mountain pine forests were the most heavily affected by wind and snow disturbances, probably due to a critical distribution in the sub-Alpine belt. For all pine species, stand resistance to the effects of wind and snow mainly depend on the combined effects of basal area and mean slenderness of the dominant trees. For a given slenderness ratio, damage increases strongly in lower-density stands, particularly in stands with basal areas below 10-15 m^2/ha. Stand structure particularly affects black pine stands, which present a higher vulnerability to wind and snow under even-aged than uneven-aged structures. Further research is needed to provide forest managers with more concise and empirically-based recommendations on using suitable silvicultural practices to minimize the risk of wind and snow-related forest damage.

Solving of actual and expected effects of abiotic and biotic forest disturbances in Slovak republic

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Climate change and its impacts on forest ecosystems with subsequent effect on forests management has been very urgent issue from scientific viewpoint and from socio-economic and political viewpoint as well.

The aim of presentation is results of project "Impact of climate change on the forests in Slovakia" (2003-2008). The aim of project was to extend scientific knowledge on the impacts of global climate change on forest ecosystems, specify predictions of the development of forest ecosystems under the conditions of climate change, and based on them to work out a system of adaptation and mitigation measures for sustainable forest management and fulfillment of all required forest functions as well as for the needs of strategic decisions of the sector.

We solve possibilities of adaptation of trees and forest ecosystems. Environmental changes impacts on trees and forests in Slovakia mainly on:

- Changes in bioclimatic conditions and changes in site conditions
- Changes in water balance
- Impacts on health, vitality and growth processes
- Changes in physiological processes of forest tree species
- Changes in genetic structure and diversity of the tree populations
- Abiotic and biotic injurious agents
- Changes in forest structure, ecological stability and forest functions

Mitigation of disturbance impacts: selection of forest reproductive material on the basis of disturbance dynamics and genetic properties

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Forest genetics, tree breeding and investigation of disturbance impacts on forest ecosystem have rapidly developed during the last decades. Considering the stability and adaptability of forest ecosystems all three are very important for mitigating possible disturbance impacts. Understanding the relationship between genetic diversity and genetic properties of the trees, and genetic properties and disturbance, will enable us better to predict the consequences of our actions and, hopefully, make wiser choices, to ensure viable forest ecosystems, including man made forests, for the next generations. In addition to information about properties of trees we should have knowledge about disturbance mechanisms and about interaction between them. In case of man made forests we should manage them in a proper way using knowledge about genetic properties what we have to ensure diversity between and within species. To ensure appropriate reproductive material for the future there is a need for study relations between genetics and disturbance impacts on trees and forests. There is a need for more knowledge transfer from the many studies of tree genetic diversity and disturbance regimes to the practical forest management. Possible options how to ensure forestry with valuable regeneration material will be proposed by presentation.

Fire risk classification of Finnish forests

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In Finland forest fires and their risks have not been a major hazard during last decades. However earlier suppression of forest fires was one of key tasks of forest authorities. In 1920´s and 1930`s also scientific and development work was carried out together with practical fire prevention work. It is notable that key targets were military. During World War II the Army Headquarters performed a massive operation mapping and classifying forests by their fire risk. The result of the work was "Fire Defense Atlas", the first and largest fire risk classification of Finnish Forests.

After WWII forest fires and their risks gradually decreased due effective fire suppression, building of forest road network and changes in forest structure. In recent 15 years there has been a revival of forest fire research and development activities. The role and use of fire in biodiversity management has raised interest but also future scenarios in global warming and land use issues suggests that forest fires can be a larger problem in future – as they already are in many neighboring countries.

We have tried to summarize the recent research and development activities in practical guidebook for fire officials and foresters. In guide we have classified the Finnish forest fuels and describe their characteristics and average loads in different site types. We have constructed a hierarchical fire risk classification for different forest stands. The classification is based on common variables used in forest management (site type, age/development class, tree species). In future development work these classes can be connected to modern forest management systems and thus provide e.g thematic maps of fire risks and even on-line maps in real situations. In general the knowledge and understanding of fuels, fuelbeds and their effect on flammability, fire risk and fire behavior will raise professional skills of firemen and their ability to perceive different forest fire operation and choose the best extinguishing tactics in different situations. Increase in these kind of professional skills are also useful in prescribed burnings, especially when their scope is currently widening to different site types and various fuel loads.

Response of bryophyte communities following logging, wildfire and spruce budworm outbreak in the Acadian forest region, eastern Canada

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The current understanding of how understorey plant assemblages respond to different disturbances is mostly limited to short-term wildfire-logging comparisons of vascular plants. In this study we explore patterns of species density and composition of four bryophyte guilds in young forests (approximately 40 years old) regenerating after clear-cut logging, wildfires, and spruce budworm outbreaks in the Acadian forest region of New Brunswick, eastern Canada. Although being similar in overall species density at the scale of 1000 m^2 all three young forest types had fewer species than mature reference forests. All groups were found to be compositionally distinct. Stands developed after spruce budworm outbreaks had the highest canopy closure and the highest amount of coarse woody debris. These stands had similar number of woody debris species as mature forests and an overall species composition that was most similar to mature forests. Wildfire-disturbed sites were characterized by a high litter cover, as a consequence of the larger deciduous component of the canopy. Finally, young managed forest had the highest number of forest floor bryophytes at the scale of 100 m^2 but was compositionally very far from mature forests in their woody debris flora. In conclusion, young seral stages of forest succession following different disturbances seem to have complementary roles in maintaining landscape level diversity, but if natural disturbances are eliminated certain species (e.g., among the epixylics and treebase species) might become more restricted to older stands in the landscape.

Vegetation recovery after fire disturbance

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The impact of fire to vegetation is strongly related to fire intensity and frequency. It determines the amount of surviving trees, ground vegetation and by affecting the soil – number of survived seeds, vegetative organs in the soil and soil suitability for germination. All these are also affected by human activity, which also could be called as second disturbance to the forest. By removing all lying and standing trees the light conditions are changed, also important nutrients are removed from the area – burned wood left to the forest is an important source of easily assimilated nutrients. Double damaged (fire disturbance followed by clear cutting) area may therefore be subject to erosion and reestablishment of forest complicated. Followed from the latter, forest management in fire damaged areas should be carefully planned.

In the research four different managements were applied to the burned areas: 1) burned and not cleaned, 2) burned and partly cleaned, 3) burned and cleaned, 4) control. Removing all dead and alive trees and ground vegetation from vast areas and sudden exposure to the light led to vast spreading of *Calluna*, *Molinia caerulea* and *Pleurozium schreberi*, which prohibit the propagation of seeds. Partly cleaned forests with varied light conditions provided protection from wind and acted as seed catchers, also as seed trees (if alive) – regeneration was abundant on partly cleaned areas. Applying selective cutting to fire damaged forests reduces the risk of double disturbance and enables sustainable forest management.

Key words: fire disturbed areas, ground vegetation, regeneration, forest management

Carbon dynamics of aboveground live vegetation of boreal mixedwoods after wildfire and clear-cutting

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Live vegetation carbon (C) pool dynamics are central to understanding C sequestration of forest ecosystems. Despite its importance, how aboveground live C pools change with stand development in boreal mixedwoods is poorly understood. We quantified aboveground live C pools (i.e., trees, >4 m in height; saplings and shrubs, 1.3–4 m in height; and understory plants, <1.3 m in height) in a postfire chronosequence ranging from 1 to 203 years and a postlogging chronosequence ranging from 1 to 27 years in the boreal mixedwoods of central Canada. The tree C pool of postfire stands increased from 0 to 109.2 Mg/ha from 1 to 92 years after fire and then declined to approximately 70 Mg/ha in 140- and 203-year-old stands. Carbon pools of saplings and shrubs and understory plants also changed with stand development and stand origin. Of the three age classes compared, postlogged stands had significantly higher vegetation C than postfire stands 1 and 27 years after disturbance, but there was no difference in 9-year-old stands. Higher values of live vegetation C in postlogged stands was attributed to live standing trees left after logging and silvicultural treatments that helped trees to establish during stand initiation.

Conservation regimes affect forest structure in the Białowieża Primeval Forest, Poland in the 19th–20th centuries (poster)

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The Białowieża Primeval Forest (BPF) (Poland) is one of the few remnants of pristine European temperate lowland forests, with over a 500-year long conservation history. Historical evidence indicates shifts in the protection regimes which may have caused changes in disturbance, potentially shaping the forest structure. We address the question: How did species composition and size structure of tree populations change in the BPF in relation to shifting conservation regimes? Tree diameters in size classes were collected from forest inventories between years 1889 and 2002 covering the BPF area. Using size distributions we analyzed demographic patterns of 10 dominant tree species (pine, spruce, hornbeam, linden, maple, black alder, poplar, elm, oak, birch) in the main forest types. The change from a dominance of coniferous towards deciduous species was observed. These changes occurred throughout the area irrespective of forest type. At present, pine and spruce have been restricted to one forest type, whereas hornbeam has expanded in all forest types. The observed changes in tree species composition coincided with shifts in conservation regimes. Despite the indirect role humans played during the last 200 years in shaping the BPF structure, the tree species richness has been constant during the study period suggesting that diverse systems are more resilient and may adapt to changes in the environment.

Other presented posters

Factors influencing development of lamas growth of coniferous tress at the age of 4-6 years

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Differences in shoot elongation pattern and height increment of hybrid aspen (*Populus tremuloides* Michx. *x Populus tremula* L.) clones

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Provenance differences in above-ground biomass of *Pinus contorta* Dougl. var *latifolia* Engelm. and *Pinus sylvestris* L.

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The project is carried out in cooperation between State Forest Research Institute Silava of Latvia and University of Latvia.

The aim of the project is to obtain information about the possible adverse effects of climatic changes on economically most important tree species and develop recommendations to minimize or avoid those effects via adjustments in forestry. The data from regional climatic models are downscaled and calibrated to obtain the predictions of important meteorological parameters (temperature, precipitation, wind speed etc.) and indicators with biological meaning (length of vegetation period, number of days with certain temperature thresholds etc.) for the territory of Latvia.

The possible impact of predicted climatic conditions are analyzed, based on data about climate envelops for particular tree, insect and fungus species. Empirical data for modeling the possible reaction of trees, insects and wood inhabiting fungi as well as impact of changes in wind patterns are obtained and used to develop recommendations for necessary changes in forestry planning and practice in order to minimize or avoid possible economical loss.

The demonstrations of the results in field trials are obtained also in frames of the project: "Importance of Genetic Factors on Formation of Forest Stands with High Adaptability and Qualitative Wood Properties", financed by European Social Fund.

The project is carried out in cooperation between State Forest Research Institute Silava of Latvia and State Institute of Wood Chemistry of Latvia.

The aim of this project is to unit competence in forest research, chemical engineering and biology sectors, attracting young professionals and foreign experts, to take stock to the potential impact of the genetic factors of pine, spruce and hybrid aspen increasing the adaptability and improving the properties of wood.

For the first time in Latvia and the Baltic Sea region comprehensive study of the influence of genetic factors on branch properties in different parts of stem is carried out. This will provide the opportunity to significantly improve branching quality of fast growing trees, originating from seed orchard seeds, and in this way increase their suitability for needs of wood-processing industry. Similar improvements are predicted from the detailed analyses of chemical and mechanical properties of wood as well as wood resistance to bio-degradation for clones, selected for seed orchard establishment.