European Forestry - Fit for Climate Change?

ForeStClim mid-term conference

20 – 22 September 2010
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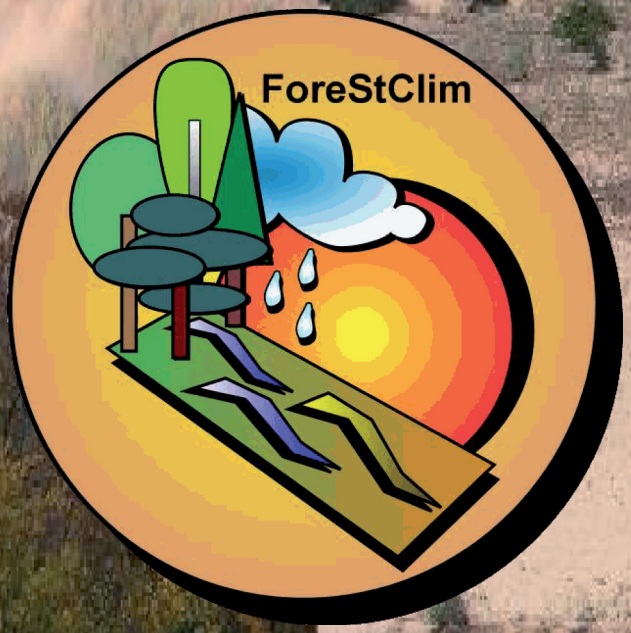

Book of Abstracts

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ForeStClim Mid-term Conference, "European Forestry - Fit for Climate Change?", 21/22 September 2010 Nancy (France)

Gebhard SCHÜLER, Thomas CASPARI & Stephan SEELING

Summary and Introduction

The European INTERREG programme is all about transnationality. And communication beyond borders is only possible if people show an interest in each other, organize themselves, come together, and talk to each other. Even in a globalized World, this will always remain a challenge.

Striving towards the aim of transnationally harmonised forest management strategies in the face of climate change, the ForeStClim project endeavours since 2008 to form a platform for 21 organisations and uncounted individuals all over North West Europe (NWE).

Now that ForeStClim is in an advanced stage of development, we are excited to invite to the project's mid-term conference. Even though the title is clearly "European", "European Forestry - Fit for Climate Change ?" is intended as an international conference. Invitations have been sent far beyond the borders of North West Europe (NWE), as climate change is a global issue and will have to be dealt with by all humankind.

The overall focus of the event is to have a results-driven meeting. It will provide the grounds for our ForeStClim partner organisations to show their progress made and milestones reached, but also the chance to discuss open and newly arisen questions with a wider audience. For participants outside the ForeStClim project it also provides a number of benefits:

- Participating in cutting-edge research in the field of forestry and climate change
- Presenting in front of a wide range of experts from all of North West Europe
- Being noticed as a potential partner for future INTERREG or related projects

Besides transnationality, INTERREG projects like ForeStClim have another major strength: they are at the interface between research on the one hand and practical applications on the other hand. Now that first results are available, the project's stakeholders will be invited to attend the meeting and share their view and concerns with the delegates. All in all, this event is seen as a unique chance to bring together people from research, development, forest management and stakeholders, to make them work with each other.

Supplemented by three parallel workshops, the conference is composed of the different thematic sessions:

- Projecting forest sites and stand shifts
- Climate change and water: modelling across spatial and temporal scales
- Addressing climate change in practical silvicultural decision support

Here, the delegates will have the chance to present their work through oral presentations or poster contributions, exchange technical know-how, but also discuss possible consequences of the results gained. The abstracts of these contributions form the main content of this publication.

ForeStClim Mid-term Conference

Session 1

Projecting forest site and stand shifts

Oral presentations

Climate change-induced shifts in broad-leafed stands: A case study of *Quercus pyrenaica* along a rainfall transect on the Iberian Peninsula

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Broad-leafed species of trees are well distributed along the Iberian Peninsula, mainly conditioned by abiotic factors, temperature and rainfall. Species of *Quercus* genera are common and can classify in evergreen (as *Q. rotundifolia*, the more abundant tree of this genera, and *Q. suber*) and deciduous (*Q. lusitanica*, *Q. pyrenaica*, *Q. robur*, *etc*.). Evergreen species are related with semiarid, typical Mediterranean conditions, and deciduous species are usually associated to subhumid or humid conditions, less conditioned by the Mediterranean summer dryness.

A case study of a rainfall transect of *Q. pyrenaica* stands are exposed to check the influence of a change of rainfall in the functioning of this forest ecosystem.

Despite of Mediterranean summer dryness, the rainfall gradient did not indicate important differences in water consumption among the coppices of *Q. pyrenaica*. Water consumption was affected more by the annual distribution of the rainfall than by the total amount of annual rainfall. Interception of rainfall by canopy was near 20 % of the bulk precipitation. The annual excess of rainfall occurs when the soil is already wet and the vegetation is dormant. Hence, this excess water results only in an increase in acidity in the soil epipedon (A_h) and an impoverishment of soil nutrients.

Higher aboveground production was obtained in the drier plot, which had a lower loss of available nutrients. Late spring rainfalls produced an increase of aboveground production in these forests.

In summary, the deciduous oak ecosystem studied has a net input of bio-elements every year that tends to neutralise the soils; an excess of winter rainfall only results in an acidification of the soil epipedon (A_h). In these Mediterranean, acid soils, the presence of sesquioxides permits the sorption of bio-elements, resulting in clean surface waters ("*arroyos*", rivers) of high quality if erosion is low or controlled. An increasing in rainfall (e. g., due to climatic change) will have slight influence on the content and quality of soil organic matter, but could acidify the soil epipedon and diminish litter production; whereas an increase of ambience temperature could have the opposite results. By contrast, a change in rainfall annual distribution could have a strong influence on the aboveground productivity of these forests, and on the mineralization and turn-over of the organic matter.

Climate changes: identification and cartography of the level of vulnerability to water stress of the main forest species of Alsace using a synecological approach

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The micro-, meso- and macro-climatic factors, combined with the water reserve of the land and the local availabilities of nutrients, are the essential abiotic factors which condition the forest stand response to the climate changes forecast by the IPCC (2007). They define the framework within which the relationships between species take place. It is this inter- and intra-specific competition, provided that it may take place free from any anthropogenic activity, which represents today and in the future the driving silvigenetic force. By inflicting intense and long periods of water stress locally on the forest ecosystems, the climate of the future will be more and more demanding and selective. It will work to recompose the plant cover and communities. Apart from any genetic considerations on the "absorption capacity" of the species and forest stands faced with such upheavals announced for the ecological conditions, we can list, using comparable climate conditions, that forests situated on land with high active storage (AS) appear better equipped to deal with the evolution of the climate and will be more resilient than those of the same type situated on land with lower active water storage which will become more vulnerable.

For this purpose, to confine the vulnerability of the main forest species faced with water stress, an original and reproducible method is proposed. It is based on a synecological approach crossed with calculations of water balances. The forestry stations are classified according to a mean active storage and placed into one of the 32 operational forestry types, issued from the grouping of 530 forestry stations identified in the 12 regions of the National Forest Inventory (NFI) of Alsace. The operational type provides a link between the 194,000 ha of mapped forestry stations in public forests. In parallel, several sets of Météo France AUREHLY data are acquired.

The crossing on the Geographic Information System (GIS) of the active storage maps with the climate data allows, using potential evapotranspiration (PE) and actual evapotranspiration (AE) calculations based on the radiative values at a pitch of 50 m, the relative water deficiency index (D%) to be calculated for over 750,000 polygons in Alsace. This results allows us to establish the ecological spectrum of dispersion of each population forming an functionnal type and thus determine the statistical thresholds of vulnerability per species, using calculations based on the reference climatological normal 1961 - 1990. The use of climate data modelled using the AUREHLY grid, using the AUREHLY data (1961 - 1990, 1970 - 2000 and 2003), of 3 models from the 3rd IPCC report [CCMA (Australian), CSIRO (Canadian), HadCM3 (English)], and three other models from the 4th IPCC report [NCCCSM (American), NIESS (Japanese), MPIM (German)] resulted in a series of vulnerability maps by species using a mix of the B2 and A2 scenarios specific to each model. It should be noted that one effect induced by the method is also to be able to identify the vulnerability of the Natura 2000 habitats, especially in Special Conservation Zones (SCZ).

Key words: dieback, Natura 2000, forestry stations, synecology, functionnal forestry type

Soil organic matter status in forest soils – site specific variations in SOM properties

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The quantity and quality of soil organic matter (SOM) and SOM pools and thus the soil properties related to carbon sequestration and water retention are not constant and thus may exhibit considerable variation through changing climate. In total changes in soil fertility and an increase in plant stress are expected. This is relevant for northwest Europe as well and may have economic and social impacts since functions of forests for wood production, groundwater recharge, soil protection and recreation might be affected.

The study is done by comparative investigation of selected sites at four watersheds that represent typical forest stands in the region of Luxembourg and South West Germany. The aim is to identify SOM storage and stability in forest soils and its dependence on site properties and interaction with tree stand conditions.

According to state of the art fractionation schemes functional C pools in forest soils and their stabilization mechanisms are investigated. In particular, distribution patterns are determined depending on location, tree stand and climatic conditions. The aim is to identify characteristics of SOM stability through fractionation of SOM according to density, particle size and chemical extractability and their subsequent analytical characterization. So far, reasons about the origin, composition and stabilization mechanisms underlying the different SOM pools are not fully understood.

Patterns of distribution of SOM in relation to silvicultural use and forest site conditions are presented, as well as similarities and differences among the tree species and results in addition to passive OM pool, which is mainly responsible for long-term stabilization of carbon in soils. These findings are aligned with selected general' soil properties such as pH, C/N, CEC and texture.

Projecting changes in forest site types in the future climate of Britain

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The cool, moist, oceanic climate of Britain's uplands, has in the west of the country promoted the development of poorly and imperfectly drained soils, e.g. surface-water gleys, peaty gleys, and thin blanket peat, which are characterised by long periods of anaerobiosis in winter months. In the east, sandier textured forest soils also occur in the uplands, and are frequently indurated, leading to shallow rooting, as a result of periglacial processes during colder, post-Quaternary, climatic periods. Significant forest expansion occurred during the 20th century, on the cooler wetter and less valuable agricultural land, typified wetter upland soils, from less than 5% of land cover before 1920 to about 12% by 2009 (Anon, 2009). Climate change is projected to influence forestry practice on these sites types (Ray, 2008a, 2008b). Projected wetter winters are likely to cause longer and more severe anaerobiosis (Nisbet, 2002), causing a reduction in rooting depth (Ray & Nicoll, 1994), an increase in wind disturbance in plantations (Quine & Gardiner, 2002), a corresponding increase the risk of bark beetle damage (Broadmeadow et al., 2009), and a potential reduction in rotation length . Observations show that drier summers and wetter winters have increased over the last 100 years, and regional climate model projections which show that this trend will continue through this century (Broadmeadow et al., 2009). Therefore it is very likely that the future climate will also exert more severe drought stress on trees with less well developed root systems, particularly in the drier eastern areas of Britain.

The United Kingdom Climate Impacts Program (UKCIP) regional climate projections provide climatic inputs into the forest classification system used in Britain - Ecological Site Classification (ESC) (Pyatt, Ray & Fletcher, 2001). Spatial and temporal climate simulations for a range of emissions scenarios show how abiotic impacts can be estimated, leading to guidance about when and where a climate change adaptation response (e.g. changing species selection) might be appropriate (Broadmeadow et al., 2009). Climate projections published by UKCIP in 2009 (United Kingdom Climate Projections 2009 – UKCP09) offer new possibilities in estimating the future variability of climatic events, and the impact of those events through the use of forest site vulnerability assessment tools by forest managers.

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Interaction between Beech and Douglas fir: Intensive monitoring at demonstration site Merzalben, Palatinate Forest

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Present forest establishment and rejuvenation has to consider the predicted changes in climate. Species which are possibly well adapted, flexible or indifferent against climate change have to be identified. Forest management strategies promote mixed forests in terms of risk minimisation or biodiversity support, instead of well adapted indigenous tree species' monocultures. But these strategies are lacking in scientific background. Knowledge on intra- and inter-specific physiology and growth of forest trees is not sufficient to decide which tree species could be appropriate for future forestry and nature conservation, because knowledge on growth (yield tables) is often gained on monocultures.

At a study site in Merzalben near Kaiserslautern (Pfälzerwald, Rhineland-Palatinate, South western Germany), direct interactions between Douglas fir (*Pseudotsuga menziesii*) and European beech *(Fagus sylvatica*) are being investigated in pure and mixed stands. Douglas fir and beech are presumed to have similar ecological niches. Douglas fir is supposed to be highly productive under the expected drier climate conditions in Central Europe and is favoured by wood producers due to its enormous seasonal growth.

The site covers a pure stand area of each species (intra-specific competition), as well as a transitional zone, where Douglas fir and beech individuals are mixed and interact (inter-specific competition). Douglas fir was planted about 50 years ago, beech - arising from natural rejuvenation - is aged about 55 years.

An intensive monitoring programme captures a multitude of morphological and eco-physiological parameters (biomass and production; allocation patterns as competition indicators; xylem sap flow, transpiration and soil water budget; water use efficiency, retrospective growth and stable isotopes; element concentrations and nutrients) investigating intra- and inter-specific growth patterns and interaction of Douglas fir and beech. Results could reveal which species possibly prevails in the future and at best lead to recommended proceedings in terms of forest establishment and silviculture.

Tree biodiversity enhances growth response to CO_2 enrichment in temperate forest

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Anthropogenic activities are increasing atmospheric CO_2 concentrations and significantly contributing to global biodiversity loss [1,2]. Forest ecosystems occupy one third of the terrestrial surface of the earth, with forest soils and biomass storing approximately 40% of terrestrial biosphere carbon[3,4]. In forests, fine root turnover is a major contributor to belowground C storage[5] and C flux[6]. Despite the importance of forests in the global C cycle, the interactive effects of biodiversity and elevated atmospheric CO_2 on temperate forest productivity remain poorly understood. We established long-term CO_2 enrichment studies with monocultures or a three-species mixture of *Fagus sylvatica, Betula pendula, Alnus glutinosa* and were able to definitively show that overyielding at higher diversity levels is altered by elevated CO_2. Under ambient CO_2, aboveground and fine root biomass was greater in the three species tree mixture than that predicted from the biomass of the single species, showing a positive interactive effect of multiple species on productivity. Under elevated atmospheric CO_2, the belowground overyielding in the three species mixture was increased, whereas the effect on aboveground biomass was similar under elevated and ambient CO_2. Our results provide some of the first clear evidence that tree biodiversity will not only mediate the aboveground response to high CO_2, but also make a major contribution to C input in to soils through the fine root biomass in a CO_2 enriched atmosphere. Reductions of tree biodiversity due to land management and global change factors such as drought and temperature change, may weaken the ability of forests to sequester C, potentially creating a feedback loop with global implications.

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Detection of drought stress by means of remote sensing in a climatic sensitive forest site in the Eifel low mountain range

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The exceptional dry and hot summer in Europe 2003 showed apparent effects on forest ecosystems. Thus, especially for the low mountain ranges in the south western part of Germany extensive damages on trees caused by the dry climatic conditions have been reported by the state forest services. Particularly spruce and beech stands reacts sensitive to drought stress. This is of interest since recently published climate models predict an increase of drought periods in Central Europe. Within this context it is from great interest to study the effects of prolonged drought events on different tree species and tree communities, considering stand variability and growing conditions to assess their resilience towards climatic change. This is essential to design and realize sustainable forest management plans adapted to the climatic circumstances. Thereby, remote sensing data offer great potential to derive and evaluate the effect of water stress on forest communities and to calibrate and adjust forest growing models.

In this study well-established methods for deriving leaf water content from satellite imagery were applied to the “Donnersberg”, a climate sensitive forest site between the Rhine-Valley and the Palatinate Fore*st* low mountain range (Rhineland-Palatinate, Germany). Several leaf water sensitive indices, e.g. the Normalized Difference Water Index (NDWI), were calculated on the basis of Landsat TM data for the drought year of 2003 and a reference year representing “normal” climatic conditions. The results were stratified for different tree species based on a spatial adaptive classification approach (developed by the remote sensing department of the Trier University), considering the eco-regional and phenological characteristics of the heterogeneous landscape like the Eifel low mountain range. On the basis of the classification results and the detection of forest sites affected by water stress the extent of the reported drought damages is assessed and its spatial distribution is documented. Additionally the drought-sensitivity of beech and spruce stands within the study area was analyzed and compared considering slope and aspect.

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Session 1

Projecting forest site and stand shifts

Poster presentations

Change detection of forest areas with satellite images

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To achieve economic and sustainable forest management, providing detailed information about the development of forested areas is an essential goal. Analyzing the area corresponding to the municipalities Ruwer and Konz, total forest area is detected, including public and private forests. The latter are undocumented until now. The input data consists of images acquired by the military satellite system CORONA in 1962 (resolution: 10 m x 10 m), and satellite images acquired by the SPOT-5 system in 2009. Furthermore digitized topographic maps from 1961 (Konz) and 1962 (Ruwer) and data from the feature type catalogue ATKIS (Amtliches Topographisch-Kartographisches Informationssystem / official cartographic and topographic information system) are used. To map total forest area, the images are first georeferenced and segmented using an object-based approach. In a second step, visual classification under consideration of the topographic maps and ATKIS – data is performed, followed by calculation of the forest area. These results are fed into statistical analyses.

Carbon Dynamics, productivity and efficiency of a beech forest under climate change - a simulation study at individual and stand level for a NWE region

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As part of the research programme 'Transnational Forestry Management Strategies in Response to Regional Climate Change Impacts' we focus on uncovering growth patterns influenced by changing climate conditions as well as on the simulation of different adaption strategies by using the forest growth models BALANCE and SILVA. In a first step, the growth model BALANCE has to be adapted and validated for selected NW-European regions. Afterwards scenario simulations can be done to analyze forest growth, carbon sequestration, productivity and efficiency of NW-European forest stands depending on climate change scenarios. Different management strategies can be tested to adapt the forests to possible future climate conditions by using the model SILVA. This way, this study can provide useful information for planning and management of NW-European forests, which will be supportive for forest economic and environment political decisions.

The first NW-European sites which will be simulated are located in the Palatinate Forest in the south of Rhineland Palatinate. It is in a low-mountain region located from 49002' to 49037'N and 70301 to 8009'E and extending southwards to Northern France. The Palatinate Forest is one of the largest continuous forests in North West Europe covering 1,798 km^2, 75 % of which is forest. One of the test plots is a pure beech stand, situated near Merzalben, a municipality in the Südwestpfalz district.

The used growth model BALANCE is an eco-physiological growth model whose primary task is to calculate three dimensional developments of individual trees or forest stands under variable environmental conditions including climate and CO_2 concentration. The 3-dimensional development of the individual trees respectively of the forest stand is estimated based on the biomass increase of the woody tissue that has been accumulated during the year. The simulation of the carbon, water and nutrient balances of individual trees form the core processes of the model BALANCE (Grote and Pretzsch 2002, Rötzer et al. 2005, Rötzer et al. 2009, Rötzer et al. 2010).

In BALANCE, some species specific parameters (Rötzer et al. 2010), such as the minimum and maximum specific leave area or the maximum water conductivity, are identified as leverage points of the model. These are parameters whose value can significantly affect the output of BALANCE, as for example height, diameter, biomass, or the water balance of trees. One-at-a-Time (OAT) sensitivity analysis is used for sensitivity analysis of BALANCE to test how the species specific parameters influence the behavior of the model.

According to the sensitivity analysis the model BALANCE has to be adapted to the local conditions. In a further step, simulation results are compared with measurements to validate BALANCE. After model calibration and validation, tree growth, biomass increment, water balance, C-dynamics, productivity as well as efficiency of the beeches will be simulated by BALANCE. These simulations, both on individual tree and stand level, are done for present and future climate conditions which are based on the outputs of WETTREG-scenarios.

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Biomass (growing stock) and production of Beech and Douglas fir

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To estimate the existent biomass (growing stock) and productivity of the beech and Douglas fir pure and mixed stands at Merzalben demonstration site, relevant parameters (abundance, diameter at breast height, tree height, radial growth, leaf mass, litter fall, fine root mass) are measured. Data are collected in a GIS database together with further stock structural information (density of individuals, vertical crown projection). Using appropriate allometric functions tree biomass and seasonal growth are calculated to find possible intra- and inter-specific differences. The collected data will be used for parameterisation of the eco-physiological forest growth simulation model BALANCE (in cooperation with TUM), to predict the stand development considering species' and individual's interaction.

Water Use Efficiency (WUE) of Beech and Douglas fir

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Under the predicted future climate conditions tree species which are highly productive in terms of lower water availability are required. Douglas fir, a neophyte from Northwest America is favoured by wood producers, due to its enormous seasonal growth. Douglas fir is expected to be better adapted to drought and heat than indigenous beech.

Water Use Efficiency (WUE), the ratio between growth (or assimilation) and water use, could be an appropriate indicator for a species' competitiveness under particular climate conditions. A species with high WUE (concerning plants of similar habitus) will be the stronger competitor, if water is the limiting factor of a plants' growth. WUE can be calculated as WUE of production (ratio of seasonal growth and seasonal water use), instantaneous WUE (ratio of actual C-assimilation and H_2O use; actual photosynthesis) and retrospective WUE by $\delta^{13}C$ analysis of tree rings.

At study site Merzalben Douglas firs' and beechs' inter- and intra-specific WUE spectra are investigated, to possibly be able to assess species' reaction under changing climate conditions.

Xylem sap flow, transpiration and soil water budget of Douglas fir and Beech

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Inter- and intra-specific seasonal transpiration of Douglas fir and beech is intensely investigated at study site Merzalben near Kaiserslautern, to assess their water budget and to calculate water use efficiency.

Sap flow density (= sap velocity in g cm^{-2} min^{-1}) is being measured seasonally by Granier's thermal dissipation method within the outermost 2 cm of the sapwood in 10 beeches and 10 Douglas Fir (5 individuals in mono-, 5 in mixed stand for each species) . For shorter periods the sap velocity in deeper sapwood was captured randomly. Highest sap velocities in beech and Douglas fir were found within the outermost 2 cm of the sapwood, decreasing inwards. To estimate transpiration the decrease of sap velocity as well as sap wood/heart wood ratio is considered. Transpiration driving variables like vapour pressure deficit are very well correlated to sap flow density at days of direct radiation.

Douglas fir and beech show differences in sap flow density between pure and mixed stand. Douglas fir has slightly higher sap flow density when interacting with beech, which indicates less competition for water resources. In contrast beech sap velocity is considerably lower under inter-specific interaction and competition for water is much stronger than in pure stand. Competition for water is connected to various soil water content and interception of the three different stands.

Competition between European Beech and Douglas fir

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Inter- and intra-specific competition of Douglas fir and European beech are intensely investigated at study site Merzalben near Kaiserslautern. Various structural biomass parameters indicate high interference concerning above as below ground growth conditions.

Above-ground competition effects are revealed by different allocation patterns of pure and mixed stand individuals. Beech trees in the mixed stand are higher and thinner than in the pure one. Fast growing Douglas fir forces beech to invest into height growth at the expense of radial increment to avoid shading. This leads to increased growth for both species under inter specific compared to intra specific conditions.

Anyhow, beech trees in the mixed zone produce a larger fraction of shade leaves which are more efficient under diffuse light conditions. The specific leaf area (SLA) of upper crown leaves in the mixed stand is significantly higher than in the pure one. This indicates a shading effect by Douglas fir, protruding beech about 3-5 m. Inter-specific competition effects on Douglas fir are shown by varied needle degree and branch angles. Above ground productivity, allometerically determined, however, doesn't show negative inter-specific competition effects. In fact crown exploration is improved and aerial biomass production of both species is slightly increased in the mixed stand.

Subterrestrial competition for resources of water and nutrients are shown by inter-specific effects in the mixed zone. Beech fine roots are suppressed into deeper, humus-poor soil regions. Related to a defined soil volume Douglas fir fine root mass is higher in the uppermost soil area where the nutrient availability is better compared to intra-specific conditions. In contrast to beech Douglas fir benefits from belowground inter-specific interaction. Same situation arises after re-colonisation of root-free ingrowth cores. This points to competition for similar soil resources and exactly the same ecological niche of Douglas fir and beech.

Appropriate competition indices classify these species' interaction into different behaviour: beneficial effects in above ground biomass growth and strong competition for same resources till hampering effects for fine roots.

Element concentrations in leaves, litter and fine roots of Beech and Douglas fir

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Element concentrations (N, P, K, Ca, Mg, Fe, Mn and Zn) of leaves, needles, litterfall and fine roots were investigated for Beech and Douglas fir under inter- and intra-specific competition at study site Merzalben near Kaiserslautern. Samples were taken according to ICP-Forest Manual. The concentrations of leaves and litter fall (separated in litter and wood of the main tree species) were compared in 2008 and 2009 (beech leaves also 2010). These data allow to compare nutrient concentration in different organs (e. g. differences in fine roots and leaves under intra- and inter-specific conditions) and litter of the main tree species. Also it is possible to calculate the element loss and nutrient cycle of the tree layer under differing competition.

Stable isotope analysis in tree rings of Douglas fir and Beech

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Tree ring width of two Douglas fir and 30 Beech individuals (under intra specific conditions) outside the demonstration site were cut in winter 2009 and 2010 in course of forest thinning. Tree discs at breast height were scanned and ring width measured with aid of WinDendro density (Regent Instruments Canada). Afterwards selected discs were separated in the last twenty year tree rings. Wood as well as from wood extracted cellulose are analysed with aid of Isotope Ratio Mass Spectrometer to gain $\delta^{13}C$ ratios.

These ratios were correlated with climatic data like precipitation, VPD and temperature during the last twenty years.

Under consideration of air CO_2-concentration and $\delta^{13}C$ of air in the last twenty year period the water use efficiency of these trees are calculated (see also Poster Water use efficiency).

These investigations should be expanded in the next years to look at variance and changes in WUE of main tree species (Beech, Oak, Scotch Pine and Douglas fir) in West-Europe during the last decades. Variance with climate conditions will deliver information of water use efficiency in the past. These information will help us to assess the prospective growth reaction and competitive effort under changing climate conditions.

Genetics of Douglas fir (*Pseudotsuga menziesii* Mirb. Franco) in the ForeStClim experimental plot Merzalben (Germany)

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In view of the ongoing climate change, the tree species Douglas fir (*Pseudotsuga menziesii)* must be attributed an eminent role by potentially and at least partially substituting the indigenous coniferous species which are assumed to be affected seriously according to the relevant IPCC climate scenarios (in particular the economically important Norway spruce *(Picea abies)* as well as Scots pine *(Pinus sylvestris)*).

It is well known that Douglas-fir has developed post-glacially two races in the original distribution range in NW-America, *i.e.* the coastal race along the Cascade and the Coastal Mountain Ranges and the interior race covering the area within the Rocky Mountains). Since they differ in their traits concerning tolerance/resistance/vulnerability towards drought, heat, bio-pests and other stressors, it appears target-aimed to get to know which Douglas fir race the Merzalben population can be attributed to. This is even more relevant since no documented data on the reproductive material used for establishing the stand is available presently.

In order to overcome this restriction, a genetic study was performed by applying selected isozyme gene markers which discriminate between the two races on the one side and contribute to the level of genetic diversity of the Douglas fir population on the other side. For this procedure, a total inventory was carried out including all Douglas fir trees in the plot.

As has been well proven by a bulk of related studies on other Douglas-fir stands, coastal Douglas-fir is the race which grows excellently in southwest Germany, while populations related with the interior race are highly problematic under present environmental conditions. The Merzalben Douglas fir population shows coastal race genetic characteristics. Moreover, data concerning the level of genetic diversity of the Merzalben Douglas fir population as compared to a number of regional Douglas fir stands which have been characterized and identified recently will be presented.

Particularly in view of the climate change problem, identifying the genetic background of the Merzalben Douglas fir monitoring stand is assumed to be of highest priority. This study may also contribute to the activities of the recently established Douglas fir task force.

KlimLandRP:
Climatic suitability maps for the main tree species in Rhineland-Palatinate (Germany)

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Impacts of climate change concern all environmental fields and all land use types, whereby the effects on the regional level will be different and specific. Which effects, risks and chances climate change can cause in Germany's federal state Rhineland-Palatinate and which possible adaptation options can be developed, is being examined in the project "KlimLandRP" (Climate and Landscape Change in Rhineland-Palatinate).

In order to develop state-wide statements for a future-oriented landscape management, an integrative project approach with five modules is applied: The basic modules water and soil deal with questions of water balance, stream water flows biocenosis, erosion and humus balance. The land use modules forest and agriculture deal with site shifting and adaptation potentials of tree species and cultures, including the influence of abiotic and biotic factors and thereby identified conflict areas. The transverse module biodiversity focuses on the influence of climate change on species and habitats. KlimLandRP works in network with different universities and institutions, as well as it strives for synergies with other projects as ForeStClim.

Rhineland-Palatinate is Germany's federal state with the highest forested area (42 %) and is rich in characteristic forest landscapes like the Palatinate forest, Hunsrück and Westerwald. Based on different IPCC-Emission scenarios, different regional climate models, and two time stages (until 2050 and until 2100), insights about the expected consequences and effects of climate change in Rhineland-Palatinate forest should be acquired. Therewith, a corridor of managing options should be delineated e.g. on the tree species selection, stand suitability or forest nature conservation. In the context of the problem complex climate change/ forest use/ nature conservation it is also to concern the social-empiric perspective through integration of the regional stakeholders.

In general, the methodical approach consists of a confrontation analysis of the climatic requirements of the main tree species with the changing stand conditions, aiming a GIS-based vulnerability analyse of the Rhineland-Palatinate's forested areas. More specifically, the method is made up of the integration of several procedures (self developed or published). In progress is e.g. a climate sensitive forest growth simulation of the most relevant forest types and forest landscapes, the extrapolation of bio-climatic envelops for the main tree species under different climate parameters combinations, a water budget simulation for typical forest soils, a climatic suitability mapping for the main tree species (see below) as well as several case studies on different spatial resolutions.

The current poster presents the approach of the climate suitability maps as well as the first results for the species *Fagus sylvatica* in Rhineland-Palatinate. The approach consists of the combination of the evaluated occurrence and site class of the tree species in the different climate combinations (combinations from mean annual temperature and mean precipitation on the growing season), leading to a classification of the species suitability to the different climate zones. Such insights are subsequently extrapolated to the future forest climate.

ForeStClim Mid-term Conference

Session 2

Climate change and water: modelling across spatial and temporal scales

Oral presentations

Afforestation Effect on Water Yield over China

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Afforestation has been encouraged worldwide since increasing demand on its diverse benefits. Especially in China, large-scaled afforestation has been taken place since decades and will be further stimulated as a measure of carbon sequestration. However, there is an increasing debate about the adverse effect of water yield reduction. This must be considered in forestry development strategy and policy-making with high priority in dryland regions. This paper tries to estimate the water yield variation with afforestation across China, based on an overview of worldwide studies. Paired catchment study (PCS) is the classical approach to evaluate forest effect on water yield, but limited for a direct use in China, because it is site specific, small scale and time-consuming. In addition, the precipitation in PCS sites of other countries is usually much higher than in China. Thus, a statistic approach was proposed to link the annual precipitation (P), evapotranspiration (ET) and forest coverage (C) of watersheds: $ET=ET_f \cdot C \cdot P+ET_{nf} \cdot (1-C) \cdot P$. After testing the applicability with PCS data, it was fitted based on the data collected from literature and used to evaluate the water yield change in 5 regions of China. It showed a big regional difference. Increasing forest coverage will reduce the mean annual runoff (MAR) from watersheds in the warm regions (warm-humid south China, warm-dry and stony north and northwest China, warm-dry Loess Plateau with very thick-soil), but surprisingly enhance the MAR in the cold-humid regions (northeast China, southwest China with high elevation). Based on the calculated MAR under 0% and 75% of forest coverage, the absolute and relative MAR change are -523 mm (-42%) in south China, -196 mm (-73%) in north and northwest China, -17 mm (-44%) in the Loess Plateau, 126 mm (168%) in southwest China, and 353 mm (68%) in northeast China, respectively. The MAR increase may be caused by the fog/cloud-drip interception by forest canopy in the mountainous regions. It is inevitable that a big uncertainty still exists due to the limited quantity and quality of data, however, these results may be enough to show the regional difference in runoff response to afforestation, and this has an important significance to locate the priority regions of afforestation, to select the suitable vegetation type (trees, shrubs and grasses) in erosion control, to help the trade-off between the water consumption and related benefits of forests, and to the right land-use decision.

Key words: China; forestry; afforestation; water yield; watershed management

Runoff generation in forestry areas: field experiments and validation of an assessment tool

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At present time it is common to use different kinds of hydrological models or GIS applications to identify or simulate runoff generation. Otherwise, especially the spatial variability of soil conditions and a lack of essential soil data make it difficult to identify the specific mechanism of discharge generation at the plot scale or even at the catchment scale. Especially the hydrological interactions between forest stands and soils are largely unknown. For this reason, sprinkling experiments combined with infiltrations and multi-attribute soil analysis are still a basic prerequisite for a realistic and knowledge-based assessment, which offers also the possibility of validating models in a second step.

Within the EU Interreg IVb Project "ForeStClim" four forested catchments (Frankelbach and Holzbach, GER; Weierbach and Huewelerbach, LUX) are under soil-hydrological investigation. The different research approaches like soil mapping, soil sampling with sampling cylinders (100 cm^3), infiltration as well as sprinkling experiments have the objective to improve the understanding of process generation taking place inside forest soils and to determine specific data for further validation of hydrological models and GIS-applications.

In all investigated catchments several different runoff processes have been identified. Soils under 30 year old afforestations still had comparable physical conditions and consequently similar discharge generation processes to the former agricultural soils. The soils under established forests were partly porous with high infiltration and water conductivity rates, and consequently reduced incidence of surface runoff, but compact layers in subsoil regions hindered or even prevented vertical percolation. The subsurface flow above impermeable soil layers might therefore contribute to flood generation. Hence, the soil conditions were confirmed as the crucial factor for runoff.

The presented results of this research can also enhance assessment tools and GIS applications e.g. to identify dominant runoff processes at the mesoscale, especially in forestry areas, where detailed soil data is not available and mapping exercises is uneconomic. The improvement of these approaches is the objective of further studies.

Investigation of the spatial distribution of runoff generation and soil erosion processes by means of experimental methods in forested small-catchments

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According to research results of the last decades forests can contribute appreciably to the genesis of flood events and soil erosion processes, mainly depending on their management and relief position. This fact is becoming crucial when facing the expected climatic change, considering the presumed increasing frequency of heavy rainfall events in winter. Therefore, it is more and more important to get a spatially distributed quantitative understanding of the processes occurring within a forested catchment. Hence, a combination of several experimental methods addressing different processes has been applied within three forested catchments, the Huewelerbach in Luxemburg as well as the Frankelbach and the Holzbach in Rhineland-Palatinate, Germany.

Experimental measurements as well as mappings of geomorphodynamics and soils were carried out in order to assess the spatial variation and intensity of runoff-generation and soil erosion processes.

The used experimental methods are a slope-scale and a small-plot scale rainfall simulator, single-ring infiltrometer measurements and rill erosion experiments.

By means of the slope-scale rainfall simulator overland flow, as well as subsurface flow in two different depths is measured, whereas the plot scale rainfall simulator measures overland flow generation and suspended sediment load. The infiltration measurements with a single ring infiltration device with float-regulated water height delivers data on infiltration capacity of the soils.

By means of the rill erosion experiments the effectiveness of the studied harvester tracks as flow paths for concentrated overland flow is tested as well as the erosion in these tracks. The rill erosion experiments enable a comparison of the processes and erosion amounts produced in the rill or rut for a defined runoff inflow. The catchment of the rill is approximated in order to enable an estimation of the water amounts that might reach the rill during heavy rainfall events. The reaction of the rill catchment is tested by means of the rainfall simulation experiments and infiltration measurements.

By means of all these experimental measurements in combination with a detailed geomorphologic mapping, it becomes possible to determine the spatial distribution of overland-flow generating areas and the occurrence of possible soil erosion processes in the study area.

Forestation-caused runoff reduction in a mountainous watershed of northwest China

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Forestation has been encouraged worldwide due to increasing demand for forest products and ecological services such as carbon sequestration and soil and water conservation. However, forestation would cause a reduction in runoff, which would aggravate the water shortage in arid region. In order to quantitatively estimate the possible water yield reductions caused by forestation in arid region, a small watershed called Pailugou in the Qilian Mountains in Northwest China was chosen as study area. The responses of hydrological dynamics to different forestation scenarios were simulated using TOPOG model. The results showed that forestation could lead to a complete loss of runoff at site scale. At watershed scale, an increase of forest coverage by 10% led to a runoff reduction of 25.6 mm, which accounted for 13% of the runoff in the modeled watershed without forest. However, the climate- and landform-regulated potential forest distribution occupied only 46.3% of the watershed area; therefore, the maximum runoff reduction was estimated up to 60% if forest cover ratio increased from 0.41% to 46.1%. Now, the forest coverage is 36% in the small watershed, thus the water yield will be continuously reduced with further increase of forest area. Our study also suggested that a trade-off between the numerous benefits of forest coverage increase and its negative impact of water yield reduction should be notably addressed in the arid region with inherently severe water-shortage.

Key words: dryland region, water yield, forestation, watershed scale, site scale

Hydrological impact of mature coniferous plantation in an upland peaty soil catchment, Irthing headwaters, northern England

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Coniferous forest plantation is widespread in the upland UK and a number of studies have been carried out to investigate the hydrological implications of this land use. Such studies also now form the basis for research into the way in which response to forestry activities may alter with climate change. The UK's longest running forest catchment experiment is at Coalburn in the headwaters of the River Irthing in the northern Pennine hills of England. Since 1966 this has monitored the hydrological effect of afforestation from planting to maturity. However, as a single catchment experiment it has studied the effect of changes only in a before and after context. Within the EC funded ForeStClim project, the Coalburn microcatchment (1.5 km^2) has therefore been paired with a neighbouring grassland microcatchment (The Flothers, 1.4 km^2), both being nested within a minicatchment (Throssburn, 7.1 km^2) which discharges to the Irthing. Elevations are around 300 m in a generally muted relief and soils are peaty, typical of the Pennine hills. The aim of the project is to investigate a) the hydrological impact of a mature plantation cover relative to open grassland, and b) the hydrological response of the combined land covers at the minicatchment scale. As well as advancing our understanding of plantation impact for upland peaty catchments, the project will investigate how these impacts may alter with climate change.

- Discharge and precipitation records for the Flothers and Throssburn begin only in 2003. Catchment comparison is thus possible from 2004, albeit with some gaps in the data record. Current analysis is aimed at the following:
- Comparison of the Coalburn and Flothers microcatchments annual runoff. The aim is to qauntify variations in the extent to which the forest yields a lower runoff than the grassland, arising from the greater interception and transpiration losses of the trees;
- Comparison at the event level. The hypothesis will be tested that, as the size of the flood peak increases, the effect of the forest cover decreases. More specifically, the winter of 2009/10 has provided an opportunity to contrast the responses for a major rainfall event and an unusually large snowmelt event;
- Identification of any spatial scale effect. The way in which the forest and grassland responses combine at the minicatchment scale and differences between the response at this scale and at the microscale will be investigated;
- Variations in the comparative responses of the two land covers for periods of distinct weather conditions will be examined for indications as to how the comparative responses may alter with climate change.

The presentation will provide the initial results from this analysis.

Effects of climate change on draught stress of Norway spruce and Beech in the upper Sauerland (Germany)

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The effects of climate change on forest water balance was investigated for an afforested catchment in the montanious area of the eastern Sauerland (central Germany). Additionally to the changes in the components of waterbalance (e.g. transpiration and seepage) the focus of the project was on drought stress for the major tree species Norway spruce and Beech. Therefore the time period of 1971-2000 (development in the past), 2021-2050 (close future) and 2071-2100 (distant future) was simulated with the **Wa**ter balance **Si**mulation **M**odel WaSiM-ETH. Model validation was conducted by comparing simulated and measured values of runoff, throughfall and seepage. As an indicator for water supply and water shortage of the trees the differential transpiration ("Tdiff"), which is calculated as the daily difference between potential and actual transpiration, was used. Tdiff depends on various site characteristics like temperature, precipitation, exposition, slope, water storage and water conductivity. Current knowledge indicates, that the cultivation of Norway spruce is restricted if Tdiff reaches values of 0.3-0.4. For higher Tdiff values (0.5-0.7) a cultivation seems no longer possible.

The plausibility of the climate projections A1B/ECHAM5/CLM and A1B/ECHAM5/WETTREG was evaluated by comparing the climate data and water balance results for 1971-2000 (control) with measured climate data and simulation results obtained by simulation with the measured climate as input data (reference). While the plausibility of WETTREG scenario was mostly assured, temperature, transpiration and drought stress simulated with the COSMO-CLM scenario differed significantly from the reference.

For all examined components of the water balance considerable changes can be expected in the future: Particularly at the end of the century winter precipitation will significantly increase while summer precipitation will be constant or slightly. For both scenarios summer and winter temperatures will increase by 2-3°C. There will be significantly more runoff during winter and less during summer. Transpiration will be 52-65mm higher than recent values. However, the annual runoff will stay constant as the described trends will compensate each other.

Deficit in water supply for the major tree species Norway spruce and Beech at the study site will increase by 0.3 mm/d until the end of the century. Absolute values of Tdiff simulated with the WETTREG scenario will be in the range of 0.7mm/d for Beech and 0.5mm/d for Norway spruce. These results show that under the assumption of the IPCC emission scenario A1B (rapid economic growth, balanced emphasis on all energy sources) Beech can still be cultivated in the study area even if drought stress increasees while growing conditions for Norway spruce might worsen drastically.

Assessing the Impacts of Land use/ Land cover Changes and Practices on Water Discharge and Sedimentation using SWAT: Case study in Dong Nai watershed – Vietnam

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The Soil and Water Assessment Tool (SWAT) has been widely applied for modeling watershed hydrology and simulating the movement of non-point source pollution. The SWAT is a physically – based continuous time hydrologic model with Arcview GIS interface developed by the Blackland Research and Extension Center and the USDA-ARS (Arnold et al., 1998) to predict the impact of land management practices on water, sediment, and agricultural chemical yields in large complex basins with varying soil type, land use and management conditions over long periods of time. This study is aimed at assessing factors contributing to reservoir sedimentation, water discharge using SWAT model in Dong Nai watershed as case study. It is especially important in the Dong Nai watershed where the soil is highly erodible and forest conversion for agricultural cropping is in serious condition. This study was also focused on how soil loss was impacted when land use in the watershed resource is changed. The SWAT model was applied to evaluate the effect of main input data of SWAT (land use, soil, human practices) to soil loss in Tri An reservoir, Dong Nai watershed, Vietnam.

Keywords: Land use/Land cover change, Surface discharge, Sedimentation, SWAT, Dong Nai watershed

Development of indicators for climate change impact on water balance of forest sites in Rhineland-Palatinate, Germany

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It is expected that global climate change will also influence the water balance in Rhineland-Palatinate (SW-Germany) due to modified temperature and precipitation distribution. Consequently, the change of water balance affects economic and natural sectors. For example, forestry is endangered because biomass productivity of forest stands is closely correlated to the soil water regime. Hence, for regional forest management planners it is necessary to know how the biomass productivity of different tree species will be affected by climate change. Therefore, it is required to determine the existing link between climate parameters and biomass productivity. Until now the regional forest agency in Rhineland-Palatinate uses precipitation as primary climate parameter to detect the water balance degree of a site, which is related to biomass productivity. It is assumed, that the existing correlation between climate parameters and water balance should be revised in order to assess the impact of climate change. Because appropriate measured data is not available, a model based approach is developed in cooperation with forestry specialists, which allows to integrate the impact of climate change on water balance degree and quasi on biomass productivity in forest management planning.

The aim of this study is to develop plausible methodical components for a concept, which finally allows detecting the correlation between climate, terrain and soil parameters with biomass productivity. At first the WaSiM-ETH 8.2 model was parameterised to simulate the water balance of various forest sites. The impact of variations of climate, topography and soil characteristics on water balance was plausibly simulated. Furthermore different drought stress indices were applied to the simulated water balance time series. All drought stress indices detected years, which were dominated by dry conditions, however, the indices relating to soil water content were more selective than those relating to evapotranspiration. Using self organizing maps (SOMs) the various forest sites were classified according to the frequency distribution of the best fitting drought stress index. The new developed concept shows for future climate projections for all forest sites an increasing number of years with drought stress, and is, in contrary to the present concept able to estimate objectively and plausibly future water balance degree and thus biomass productivity.

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Climate change and water: modelling across spatial and temporal scales

Poster presentations

Influence of soil water repellency and compaction on overland flow generation in a forested small catchment in the Hunsruck low mountain range (Germany)

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Researchers have recognized during the last decades that forests can also contribute significantly to the flood and erosion dynamics depending on their management. This fact is becoming crucial when facing the expected climatic change. For this it is more and more important to get a spatially distributed, quantitative understanding of the processes occurring within a forested catchment. Accordingly, a combination of experimental methods addressing different processes has been applied in a forested low mountain range catchment.

In the catchment of the Holzbach river, situated in the Hunsrück low mountain range in Rhineland-Palatinate, Germany, experimental measurements were carried out in order to assess the spatial variation and intensity of runoff-generation and soil erosion processes. The soils in this catchment are acidic Cambisols and Podzols as well as hydromorphic soils in areas where groundwater conducting geologic strata strike out.

The soil surfaces under coniferous forest are partially hydrophobic and thus overland-flow generation is supposed to be triggered especially at the beginning of rainfall events.

The used experimental methods are a plot-scale rainfall simulator, single-ring infiltrometer measurements and rill erosion experiments, as well as drop penetration tests for the determination of the intensity of soil water repellency.

The rainfall simulator is used for a quantification of overland flow generation and suspended sediment load in the flowing water. The infiltration measurements by means of a single ring infiltration device with float-regulated water height, delivers data on the infiltration capacity of the soils. By means of the rill erosion experiments the effectiveness of the studied harvester tracks as flow paths for concentrated overland flow is tested and the erosion in these tracks can be quantified.

The rill erosion experiments enable a comparison of the processes and erosion amounts produced in the rill or rut for a defined runoff inflow. The catchment of the rill is approximated in order to enable an estimation of the water amounts that might reach the rill during heavy rainfall events. The reaction of the rill catchment is tested by means of the rainfall simulation experiments and infiltration measurements.

By means of all these experimental measurements in combination with a detailed geomorphologic mapping, it becomes possible to determine the spatial distribution of overland-flow generating areas and the occurrence of possible soil erosion processes in the study area.

Restoring sponges in the Belgian Ardennes

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This project deals with natural water retention. It is part of the Interreg IVB project AMICE (Adapatation of the Meuse to the Impact of Climate Evolutions). Floods and droughts are two aspects of just one problem. The idea is that sources areas and floodplains in the upper parts of the catchment basin can play an important role for the whole of the Meuse basin. Condition is they function in a natural way. When the bog, moor and fen vegetation is well developed it acts as a sponge for the sky-water. This presents a double benefit. First, in case of high water the flood is slowed down because the water will saturate the natural sponges first. Only when the sponge is full will the extra water flow into the brooks and the rivers. Second, as the water is kept in the sponges it also has enough time to infiltrate the soil. The water thus kept in the system presents a welcome reserve in times of drought.

In the Ardennes a number of small tributaries of the Meuse are being restored to their natural situation by cutting spruce plantations and fillling drainage ditches combined with appropriate management. The result is that the natural vegetations of sources and brooks redevelop. This can already be seen in the Emmels and Holzwarche valleys. Moreover research indicates that ecosystems that function in a natural way could very well be more resilient to the impacts of climate change.

Modelling the meso-scale using DRP-maps

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In hydrological modelling the use of detailed soil data is sometimes troublesome, since often these data are hard to obtain and, if available at all, difficult to interpret and process in a way that makes them meaningful for the model at hand. Intuitively the understanding and mapping of dominant runoff processes in the soil show high potential for improving hydrological models. In this study a labour-intensive methodology to assess dominant runoff processes is simplified in such a way that detailed soil maps are no longer needed. Nonetheless, there is an ongoing debate on how to integrate this type of information in hydrological models. In this study, dominant runoff processes (DRP) are mapped for meso-scale basins using the permeability of the substratum, land-use information and the slope in a GIS. During a field campaign the processes are validated and for each DRP assumptions are made concerning their water storage capacity. The latter is done by means of combining soil data obtained during the field campaign with soil data obtained from the literature. Second, several parsimoniously parameterized conceptual hydrological models are used that incorporate certain aspects of the DRP. The result of these models are compared with a benchmark model in which the soil is represented as only one lumped parameter to test the contribution of the DRP in hydrological models. The proposed methodology is tested for 15 meso-scale river basins located in Luxembourg. The main goal of this study is to investigate if integrating dominant runoff processes within hydrological models allows the improvement of simulation results with a view to regionalization and predictions in ungauged basins. The regionalization procedure gave no clear results. The calibration procedure and the well-mixed discharge signal of the calibration basins are considered major causes for this and it made the deconvolution of discharge signals of meso-scale basins problematic. From the results it is also suggested that DRP could very well display some sort of uniqueness of place, which was not foreseen in the methods from which they were derived. Furthermore, a strong seasonal influence on model performance was observed, implying a seasonal dependence of the DRP. When comparing the performance between the DRP models and the benchmark model no real distinction was found. To improve the performance of the DRP models, which are used in this study and also for the use of conceptual models in general, there is a need for an improved identification of the mechanisms that cause the different dominant runoff processes at the meso-scale. To achieve this, more orthogonal data could be of use for a better conceptualization of the DRPs. Then, model concepts should be adapted accordingly.

Hydrologic modelling and dendrochronology as tool of site-species adequation assessment in a changing climate context

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A hydrologic model is related to dendrochronological measurements performed in a 52 years old Spruce stand. The site is situated on a hillside with shallow and acid brown soil in the ecoregion of Ardenne (Wallonia, Southern Belgium).

Hydrologic modelling

The hydrologic simulation runs from 1971 to 2005 at daily time step. The model is based on an EPIC code, adapted to the site concerning soil reservoirs depth, characteristic water contents, root profile and water uptake. Weather data come from the Royal Meteorological Institute. Outputs from the model are real evapotranspiration, surface runoff; interflows, deep percolation and soil moisture at daily time step.

Dendrochronological study

Tree ring thickness is measured on 24 core samples extracted from 12 dominant trees of the stand. Annual increments are standardised by the ARIMA function in order to produce the annual deviation of ring thickness. Means of annual deviation for the 12 trees are then related to annual soil drought intensities.

Results

Years 1976 and 1996 are emphasised by both the modelling outputs and the dendrochronological measurements as very dry. Model shows a severe drought and tree ring shows a very low growth. Years like 1990, 1992, 1994 and 2004 shows a less severe drought event but a drought that occurs in June-July, which seems to penalize spruce's growth. On the other hand, years 1981 and 1998 show an important growth and a high value of mean soil moisture during June and July.

The poster will show how the time evolution of the ARIMA index is related to some meaningful hydrologic indexes.

These considerations will allow us to progress towards forecasting forest trees reaction to climate events and change. With this in mind, we will use a climate scenario build up in the frame of the AMICE interreg project.

The INTERREG IVB project AMICE: Adapting the Meuse river and its catchment to the impact of flooding and low waters from climate change

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'AMICE' means 'friend' in Italian and the project is all about friendship:

AMICE is all about making friends with the Meuse and helping the river to adjust to climate change. We want the Meuse to become the very best example of a climate-proof river but one that keeps its natural beauty.

AMICE is also about the people who live along the 950 km length of the Meuse and its tributaries. It means building strong relationships between the 17 partner organisations and all Meuse-lovers in the catchment - from where it rises in France to its mouth in The Netherlands via Belgium and a part of Germany. It is a dream, but with commitment and enthusiasm, it can come true.

In the future there will be more floods and more droughts. Whatever we do now, we cannot stop climate–change. Adaptation to changing circumstances is a necessity - but we can choose how we take action. AMICE gives us the opportunity to test all the options and build them into one overall strategy. The river is bound to respond in ways we know but we are also anticipating some surprises.

Increasing our knowledge base is the key to success. If we want to help the Meuse adapt we must know everything about the river and how the local climate will change. We need to review all the existing literature, test climate models, quantify the impacts of different factors and prepare good land-use maps. Using reliable climate scenarios and the shared skills of the scientists in the catchment, this international study will help us generate a better understanding of how the Meuse will respond in the future.

Water is the 21st century's essential resource. We must hold onto it and handle it with care! Improvements in 'natural water retention' can often be achieved through low impact, small-scale land-use changes. In AMICE, we are already investigating in three places how water can be held back more naturally where there are different land-use and population characteristics. This experience will help us to develop a more natural Meuse river basin.

There are many flood-water management constructions operating already in the Meuse river basin and more are planned. Herein lie some big challenges. How to design new water management structures that are able to deal comprehensively with flooding, drought and increasing water demand. How to adapt existing flood control measures to cope with ever more extreme events. Through AMICE, new approaches to these challenges are being tested by three highly innovative projects in Germany, Flanders and the Netherlands.

However, construction projects alone are insufficient to cope with some extreme water events. AMICE wants to improve how water managers and the rescue services anticipate and react to flood events. With the help of interactive software and the experience of AMICE Partners, flood crisis management can be improved and this will ultimately be tested through a transnational, flood-risk management exercise.

Change will also be achieved through awareness-raising - through newsletters, information packs, posters, leaflets and websites. Site visits to the different pilot projects will be arranged for local authorities and other participants. International events will provide an opportunity to disseminate the results of AMICE's achievements further afield. Best of all will be an AMICE film that will tell the full story of how the Meuse basin is responding to climate-change.

ForeStClim Mid-term Conference

Session 3

Addressing climate change in practical silvicultural decision support

Oral presentations

Addressing climate change in practical silvicultural decision support

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Forest Management Decision Support Systems, FORSYS, is a COST Action currently gathering 24 countries and 9 non-COST institutes. The main objective of the Action is to develop guidelines for the development and application of decision support systems (DSS) for forest management. One part of the work entails the collection of data of existing forest DSSs. Currently there are 55 entries on a wiki platform, mostly European, with descriptions of varying degree of detail (see http://fp0804.emu.ee/wiki/index.php/Main_Page). Although not complete, the repository gives a good picture of what is available and is an excellent starting point for digging into specific system capabilities, whether your task is to find a complete system, import system components or use them as templates for your own development.

What support could you then expect from existing forest DSSs when it comes to analyze climate change and silviculture? This depends on the problem at hand and the perspective you have. Obviously, the DSS must deliver data on the functional aspect thought for. If you want, for instance, to assess the fire risk of different forest management strategies, the DSS must contain a fire risk model. But there are several other dimensions that should be attended to. What phase of the decision making process is pertinent, i.e. do you need help to structure the problem, design different options or choose among a set of options? What is your position in the decision making process, e.g. are you making policy analyses as a basis for legislation or are you, as the forest owner, looking for optimal management? What forest level is relevant, i.e. do you want to analyze the prototypical stand or concerns the problem a larger forest area? Is the problem of a strategic nature or is the issue to find support for everyday, operational decisions? These are some of the dimensions that are relevant for structuring the DSSs to facilitate the identification of system and system components relevant for climate change analysis.

The presentation will look at the content of existing forest DSSs, structured in the way suggested above, against needs for adaptation and mitigation measures that, directly or indirectly, will affect the way silviculture could or should be performed.

Distributed spatial evaluation of climate change vulnerability and risk for forests in Northwestern Europe

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Against the trend to homogenize data across Europe and work with aggregated data, we develop web services for spatial evaluation that allow regional variability of data. Still we aim to bring the results of different spatial analysis in different regions for comparison of overall evaluation result while maintaining the original semantic context. We develop these services so that forest vulnerability and risk evaluation for climate change, possibly in addition to other evaluation criteria can be done in different regional context with different context specific data, with outputs shareable between regions.

The number of scientific publications on spatial multi-criteria evaluation methodology development and applications have been steadily increasing, but institutionalization in practice is weak. Various methodologies have been available in different desktop applications. Only recently some first web applications have appeared. Most of these approaches focus more on technical delivery in geo-information software applications than on supporting planners and decision makers, let be planning and decision making processes, which determine institutionalization. We review review motivations to move from desktop to web application development. Additionally we discuss our experiences with the use and institutionalization of spatial multi-criteria evaluation in several projects.

Based on this understanding of software applications and practices, we establish functional requirements for web-based spatial multi-criteria evaluation that are based on a theoretical framework of spatial multi-criteria evaluation by van Herwijnen and the adaptive structuration theoretical framework. These frameworks allow us to discuss what is 'spatial' about spatial multi-criteria evaluation and the role of technology in decision making processes. Therefore we go beyond the requirements of the multi-criteria methodologies per se, and we explore extensibility towards collaborative evaluation.

Then we will discuss a number of technological and social opportunities to develop the web application and web services in an open source community that address these functional requirements and in which spatial multi-criteria evaluation services and its development process can be embedded. Together, the understanding of current shortcomings, functional requirements and technological opportunities lead us to an extensible architecture of spatial multi-criteria evaluation web-services, which can extend within or between organizations.

We verify the functional requirements and the architecture by reviewing the practices and needs of the forest management organizations of Great Britain, Alsace and Rheinland-Pfalz with whom these web-services are being developed.

Spatial and temporal integrated assessment framework for managing forest risks and vulnerabilities caused by climate change with its inherent uncertainty

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Society is experiencing changes in the environment caused by climate change, and in the management of the environment because of the need to adapt. Recent observations show trends in the warming of the climate, seasonal shifts in rainfall patterns, and increases in the number of extreme events such as prolonged droughts and other events (Alcamo 2007). The forest industry is likely to experience the effects of climate change with an increase in tree vulnerability and susceptibility to abiotic impacts from long term climate space shifts (Ray 2002), and an increased risk of impacts on management objectives caused by droughts and other extreme events (Broadmeadow, Ray et al. 2005). Forest managers in particular have difficulties in defining suitable species and silvicultural systems over a long period of tree growth with imperfect and uncertain climate model simulations and scenarios. The project will study current, and future, forest management practices, examining and identifying those forest areas considered sensible and vulnerable to climate change impacts. Using the new UKCP09 probabilistic climate data (Murphy 2009) with its inherent uncertainty the project aims to assess key, multiple, biotic and abiotic risks spatially and temporarily, and provide practical information to forest managers for their decision making adaptive process. Our proposed approach involves the development of an integrated assessment framework at different spatial and temporal scales allowing us to target forest management adaptation advice at various institutional levels.

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Evaluation of Biodiversity in ForeStClim

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Introduction and objectives

Biodiversity is a keyword in political statements and strategies. Similar to sustainability many people are using it but with different ideas and conceptions behind it. It is also a keyword in the project ForeStClim as formulated in the application form: “Climate change will […] inevitably have a marked ecological impact on the status of the main forest species in the NWE-region and threaten the multiple benefits provided by forests. […] Effective strategies and plans to support forest biodiversity and the last close-to-nature vegetation spaces in North-West-Europe are required.” In ForeStClim main actions are the development of methods to enable:

- Risk assessment and visualization of forest development depending on the impacts of climatic change by evaluating […] the development of forest vegetation associations and the impact on biodiversity,
- Forestry strategies to react to different regional climate change scenarios […] with regard to ecology and biodiversity,
- Support of biodiversity by an adapted forest management.

Definitions of Biodiversity

The assessment of biodiversity requires a complex definition, comprising of more then one dimension. Biodiversity can be defined as “the variability among living organisms […] and the ecological complexes of which they are part; this includes diversity within species, among species, and of ecosystems” (CBD [2009a]: 4). Biodiversity within species also includes genetic diversity, which means “any variation in the nucleotides, genes, chromosomes, or whole genomes of organisms” (ibid: 5).

Hence there are several levels of biodiversity in the hierarchy of ecosystems, like biochemical elements, organisms, biocoenosis and landscape structures. And there are several degrees in the complexity of biodiversity expressed e.g. as Whittaker’s α-, β-, γ- Diversity (cf. Granke et al. [2004]: 26).

Climate Change, Impacts on Biodiversity and Adaptation to Sustain Biodiversity

“Climate change will have significant impacts on many aspects of biological diversity; on ecosystems, species, genetic diversity within species, and on ecological interactions” (CBD [2009b]: 6). The magnitude is not easily predictable. There is a big uncertainty to deal with. But we can proceed on the assumption that an increasing variety of living systems elevates the ability of adaptation. Hence decreasing biodiversity diminishes the resilience to climate change. (cf. CBD [2009a]: 7). “Molecular genetic diversity within a species, species diversity within a forested

community, and community or ecosystem diversity across a landscape and bioregion represent expressions of biological diversity at different scales" (ibid: 13).

Collection of Biodiversity Parameters

The collection of biodiversity data to assess biodiversity depends on the scale of biodiversity which has to be considered. An example of a parameter of biodiversity is the number of species in an investigation area (e.g. Beierkuhnlein et al. [2005] combined with structural parameters). Other examples of parameters are breed variety of dominant tree species (genetic diversity), number of xylobiontic beetles, succession phases (cf. Granke et al. [2004]: 26). Examples of structural diversity parameters on a landscape level could be found in Lang, S. et al. [2007].

Assessment of Biodiversity

The number of species is not sufficient to enable an assessment of biodiversity. Quantitative indicators must be combined with qualitative criteria (Granke et al. [2004]: 27). Such qualitative criteria are e.g. habitat type, hemeroby, rarity and threat of an ecosystem (ibid: 27). Granke [2004] suggests using the characteristic species composition as valuation orientation.

Conclusion

In ForeStClim a few parameters to assess biodiversity are collected by project partners in different test fields. Within the multicriteria decision analysis tool biodiversity will become part of the criteria tree to assess the ecological consequences of forest strategies in different climatic change scenarios.

Keywords: Complexity, landscape structure, adaptation, resilience, quantitative indicators, qualitative criteria

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Climatic Change and Forest Fires: Theories, Experiences and Management Strategies

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Forest fires are a natural part of many ecosystems and a frequent and expected feature mainly in boreal and dry tropical forests but rare in tropical moist forests. Presently, the geographical spread, frequency and intensity of forest fires are changing and getting larger and stronger across the globe. Climate change has altered the behavior of forest fires dramatically and has been identified as the primary driver of recent increases fire risk and intensity. This paper reviews the literature using a search methodology to evaluate (a) the vicious cycle of climatic change and forest fires; (b) the environmental, economic and social consequences of intensified climatic change and forest fires and (c) the strategies to control and mitigate forest fires to achieve sustainable forest management.

Research indicates that with climate change, forest fire season now starts earlier, fires last longer and the fire season ends later. These enhanced forest fires which are the giant carbon stores emit massive amounts of greenhouse gases when they are burnt creating a vicious cycle of forest fires and climate change. The severe drought conditions, drier forest lands caused by climate change, land use changes and lack of sustainable management of forest areas make forests more flammable, leading to ever larger and more uncontrollable fires. The structure and function of the forests are significantly influenced by forest fires. Severe fires change forest composition, vegetation structure, and biogeochemical cycles which lead to environmental degradation through impacts on water cycles, soil fertility and biodiversity. Forest fires destroy not only forests but also the buildings, crops, plantations, and even livelihoods. Fire-fighting expenditures for forest fires are regularly increased exceeding bearable limits. Severe forest fires bring critical and life-threatening levels of pollutants for respiratory and other pollution-related ailments. Forest fire research and management organizations therefore have to develop efficient and credible information systems to monitor and report on forest fire activities. The researchers should focus on the development of threat matrixes to assess the risks of forest fires as well as policies and procedures to manage these effects. Local communities have to participate in managing fires as they are becoming increasingly involved in forest management and conservation. Urgent ecological restoration and fuels management strategies should reduce forest fire hazards to human communities and mitigate their ecological impacts. Comprehensive landscape-level plans for forest and water resources management are needed to reduce risk of forest fires.

The resilience of urban trees: a case study of Runcorn, UK

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Trees incorporated into urban environments have both ecological and social values which help sustain public health and well being. What is not known is how resilient urban trees are to the challenges, including climate change, of the 21st century. If the species composition of trees in urban environments is likely to change over time then this raises questions about the effects on the ecosystem services provided. The aims of this research are to examine the relationship between trees and their role within urban environments, and to critically review the external forces that are likely to cause change. In Runcorn, a town in northwest England, large scale landscaping and tree planting that built on the existing topography and vegetation was an integral part of the town's spatial planning strategy. This planting took place between 1960 and the 1980s. The trees within these vegetated areas have reached maturity and questions are being asked about their future. In this paper the authors discuss the current floral composition of this element of Runcorn's green infrastructure and consider the affect of predicted climate change. Species lists and abundance data have been combined with the 2009 UK climate projections to produce tree landscape change scenarios to *circa* 2080. At present there are twenty seven tree species in Runcorn. Ecological Site Classification (ESC) has been used to predict future suitability for tree species within Runcorn. Results relating to the seven species presented in this paper suggest that the trees and woodlands within Runcorn are going to be altered significantly. The east of Runcorn is considered to have ideal conditions for *Betula pendula, Alnus glutinosa, Fagus sylvatica, Quercus robur* and *Prunus avium*. However, climate change predictions suggest that by the 2080 the location where these species are expected to thrive is going to reduce and relocate to the west. These species contribute 34% of the overall tree abundance and are widely distributed around Runcorn. This shift in species distribution across Runcorn and the reduction in the number of species present will have an effect on the value of green spaces to other wildlife across Runcorn. According to Southwood (1961) and Rose and harding (1978) *Quercus robur* has the highest number of associated insect (284) and lichen (324) species of any tree and shrub species. Other species such as *Betula pendula* and *Alnus glutinosa* also rank highly with regard to the number of associated insect (229-90) and lichen (126-105) species. Whereas *Fraxinus excelsior* ranks significantly lower in terms of associated insect species and have only 41. Therefore, the changes in the tree communities across Runcorn could lead to a reduced number of invertebrate fauna and as a result, could affect the number of avian fauna. With a change in tree species distribution predicted across the town land owners will need to consider implementing a strategy to deal with these changes. The paper concludes with a description of future work that will assess current management practices and measure the ecosystem services attributed to Runcorn's urban trees.

The Mersey Forest – Managing urban forests in a changing climate

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Background

The Mersey Forest partnership is involved in the delivery of a range of projects and programmes related to climate change adaptation and mitigation. (www.merseyforest.org.uk/library)

Our aim is to develop improved silvicultural guidelines for woodland owners and managers that not only ensure that our trees and woodlands thrive in a changing climate, but also that they provide a range of benefits for the surrounding towns and cities.

Economics

Most of the woodlands in The Mersey Forest (TMF) are small and not managed for the primary purpose of direct economic return (a possible exception being the Sefton Coast Woodlands); across the majority of woodlands economic potential is utilised *ad hoc*. However, in line with sound silviculture and ensuring good value for funding investment we do promote;

- Silvicultural practices that encourage straight, well-formed timber
- Species suited to the site and that are adaptable to a changing climate, and for which there is a demand in the market (discussed in Risk Diversification)
- Opportunities for various business types to conduct woodland operations (management) and market wood products

This would involve capacity building for local businesses as well as a change in outlook for some landowners.

Part of our work is looking to ascribe value to the non market benefits that these woodlands provide. Work as part of ForeStClim has shown that £1 invested in The Mersey Forest generates £10.20 of economic benefits, including climate change adaptation and mitigation benefits.

Ecology & Biodiversity

The proximity of TMF woodlands to urban areas combined with the small and fragmented nature of those woodlands means that clearfell operations are neither desirable nor appropriate. Also a continous presence of woodland cover will contribute to the mitigation of the urban heat island effect. All this works in favour of woodland ecology due to greater reliance on CCF methods.

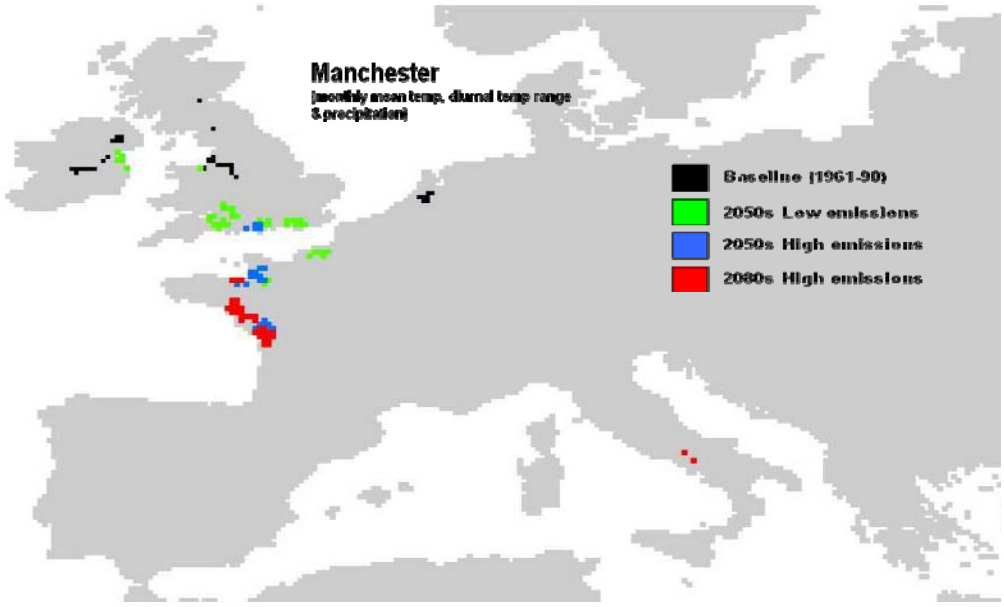
Connectivity between woodland areas is a related area that has research potential. Many field layer species that are used as indicators for ASNW or PAWS e.g. *Primula vulgaris* are highly immobile species and struggle to disperse even within a woodland.

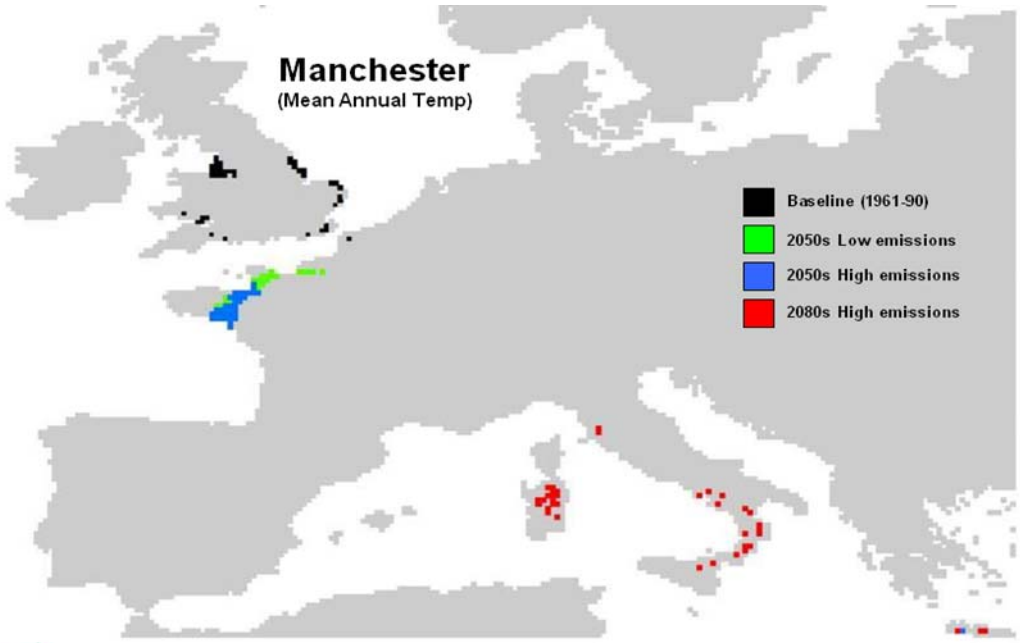
Risk Diversification

With the expected impacts of climate change the necessity for intraspecific genetic diversity is increasing. There may be scope for introducing genetic material from more southerly provenances, including from the continent, either as pedigree stock or through hybridisation work.

We have looked at two parameters to look at this issue. Forestry Commission have produced maps that indicate “Climate matches” for areas of the UK. The maps below show climate matches for a range of climate variables for a number of timeslices and emissions scenarios.

We can then compare these with Biogeographic zones and see that the projected matches are mainly within our current zone.





Forestry Commission England

Forest Research

Comparing this again to the ForeStClim Partners we can see a good match with the cluster of French partners in North West France.

ForeStClim Mid-term Conference

Session 3

Addressing climate change in practical silvicultural decision support

Poster presentations

Stand-wise forest cover mapping using a spatially adaptive classification approach in mountain ranges in Central Europe

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Economic and sustainable forest management needs periodic surveys about the state of forest. Modern forest inventory concepts are not only focused on timber production but on a variety of forest functions and services. Multispectral remote sensing data offer an attractive alternative to complement and optimize cost intensive terrestrial forest inventories. Due to high variation in forest communities, forest structure and the fragmentation of the forested area, special requirements for satellite based inventory methods in Central Europe are needed. Our innovative classification approach combines forest inventory information at stand level and satellite imagery to produce a forest cover map (five tree species: oak, beech, Norway-spruce, Douglas-fir, Scots-pine and three management classes: stand qualification, dimensioning, maturing). The spatially adaptive classification approach was applied to a heterogeneous area located in the Eifel low mountain range (Rhineland-Palatinate, Germany). To better represent the ecoregional and phenological characteristics of a given location, the classifier is designed so as to give priority to reference data from the immediate neighborhood of the location to be classified. This enables us to derive a precise forest cover map for heterogeneous and fragmented landscapes, and over large areas. Our results demonstrate that a significant increase in maximum likelihood classification accuracy can be achieved by implementing the locally adaptive classification approach for forest cover mapping. The spatially adaptive classification approach holds the potential to be implemented in regular state forest inventory procedures.

Satellite-based estimation of forest biomass in a heterogeneous low mountain range

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In respect of the multiple functions of today's forests a high need for detailed and spatially comprehensive information about different forest attributes is demanded. This is in contrast to the actual existing forest information data comprising multi-attribute information on forest-unit basis. Different tree-species, development stages and other attributes are described for each forest-unit, which are not spatially explicit within the units. Because terrestrial inventories are expensive and time-consuming, it is necessary to develop alternative methods to support forest management and forest survey. Satellite-based forest observations cover large areas at once and provide data at a high temporal repetition rate and thus, are suitable to support management decisions as well as terrestrial field surveys.

Satellite based techniques have been successfully applied in Northern Europe and North America to produce reliable forest resource information for large- and medium-size areas (e.g. forest volume).In this study we implemented the kNN-algorithm which was successfully developed and applied in Scandinavian forests to the conditions of heterogeneous low mountain ranges in Central Europe. SPOT-5 satellite data were used to estimate forest volume to Norway spruce stands in the Eifel low mountain range (Rhineland-Palatinate) by combining information provided by the digital forest inventory information system (WöFIS) and SPOT-5 reflection values. First results showed a high correlation of 0.74 between observed and estimated volume and suggests the applicability of this method to the special condition of heterogeneous forest sites.

Identifying areas of drought risk in forest: developing a tool for forestry planners - project concept

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Drought risk is based on a combination of the frequency, severity, and spatial extent of drought (the physical nature of drought) and the degree to which a population or activity is vulnerable to the effects of drought. Droughts are likely to become more frequent and severe in some regions during the expected climate change. It is expected that global climate change will influence the water balance due to modified temperature and precipitation distribution. As a result, the change of water balance affects economic and natural sectors. Forestry is jeopardized because on the one hand the biomass productivity of tree stands is closely related to the soil water regime and on the other hand drought stress reduces the tree's defences against pests.

The aim of this study is to develop an approach/tool to identify forestry areas with a high risk of droughts in the mesoscale, where data with high resolution (e.g. soil maps, forestry inventory) is not available or mapping exercises are uneconomic.

In a first step an analyses of areas with drought stress will be done by the department of remote sensing using multispectral Landsat satellite imagery of the dry season in 2003. Subsequently, analysis of affected trees species and their position in the forest will be done by GIS-analysis and soil mapping exercises. Afterwards, different studies about topology, substratum and soil characteristics of these stands will be done to derive main issues, indices and parameters for the new tool.

Afterwards, the tool to delineate drought risk in mesoscale areas will be developed based on the previous results using wide spread available data like DHM, geology, land-use and topology.

The outcoming maps will be the basis for forestry planners and stakeholders to manage their forest provident to reduce damages of trees and losses of biomass caused by droughts.

Forest susceptibility to future pest outbreaks under a changing climate in Luxembourg

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In the forthcoming decades, a significant proportion of forest insect pests are expected to expand towards new climatically suitable sites as a consequence of climate change. As a result, important damages are likely to be caused in forest stands within temperate Europe that have hitherto been unaffected by those species. Based on the hypothesis that climate is the main determinant of species distributions at large spatial scales, the potential impacts of projected climate change on the distribution of pest species are forecasted using predictive approaches.

Focusing on the main forest tree species in Luxembourg (*Fagus sylvatica*, *Quercus spp*., *Picea abies*), the distribution of their most important insect pest species (i.e. *Orchestes fagi*, *Thaumetopoea processionea*, *Lymantria dispar*, *Ips typographus*…) is modelled at a regional scale (the Netherlands, Belgium, Luxembourg, Germany, France, and Switzerland) by means of bioclimatic envelope modelling procedures using the Maxent software. The present-day geographical distribution of the insect pest species (ICP Forest data) is linked to a series of climatic parameters (Climatic Research Unit global climate dataset, University of East Anglia) that are of biological significance for the species, e.g. the annual daily temperature sum above 5°C (i.e. growing degree days, surrogate of the development threshold for many species), the mean temperature of the coldest month (related to overwintering survival) or water balance (moisture availability for the species, approximated as the monthly differences between precipitation and potential evapotranspiration). The distribution of the host trees for these pest species is considered as a covariate in the analysis.

The projection of the species-climate relationships under future climate change scenarios (HadCM3 model; A1F1, A2 and B2 scenarios; 2021-2050 and 2051-2080 time slices) provides insights into the potential future shifts in insect pest species ranges. On this basis, we evaluate to what extent the forests from Luxembourg are likely to be subject in the future to damages caused by an increasing amount of insect pests outbreaks as a result of climate change.

Potential distribution of ALB (*Anoplophora glabripennis*) in western Europe

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The ALB (Asian longhorned beetle), *Anoplophora glabripennis*, is native to China, Korea and apparently part of Japan and has unintentionally been introduced into North America and western Europe. It is an alien invasive species, as in Europe established populations have been recorded since 2001; actually, the IUCN Invasive Species Specialist Group (ISSG) considers ALB as one of the 100 of the world's worst invasive alien species. Where ALB occurs, it attacks different species of healthy and apparently stressed broadleaf trees causing mortality and hence enormous ecological and economical damage. As a result, ALB is classified a quarantine pest species in North America and Europe and drastic eradication programs have been initiated. With the goal to better understand the threat due to ALB invasion in western Europe, we have generated a worldwide bioclimate-driven species distribution model (using known ALB and broadleaf tree occurrences and the Maxent modeling tool) uncovering the potential distribution of ALB. In a subsequent step we have projected ALB's potential distribution into future climate change scenarios to identify geographic range shift or expansion. We discuss our results in the framework of monitoring needs hampering the species' expansion in our target region.