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INVESTICE DO ROZVOJE VZDĚLÁVÁNÍ

Sustainable silviculture, conversion and afforestation

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Silviculture

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Sustained-yield management

What is a crucial task of forest managers?

1. Find an optimal way how forest units (stands) can produce the goods and services of a forest;
2. To identify the principal constraints (limits) on the forestry practice;
3. To set down functions of the forest including their priorities.

These decisions helps to formulate the objects (goals) of management.

How the goals will be achieved?

There are several several methods available to be used to decide:

1) Suitable silvicultural system (clear-cutting, shelterwood, coppice, selection etc);

2) How the forest is to be divided up for purposes of management and silviculture;

3) How the yields of timber and other goods and services are to be regulated and sustained;

4) How timber is to be harvested, processed and marketed;

5) How the forest is to be designed i.e. confluence of efficiently functioning and as aesthetically pleasing forest as possible;

6) How the forest enterprise is to be organized for the best use of its resources.

Sustained yield

A sustained yield may be defined as a regular and continuing supply of the desired goods and services to the full capacity of the forest and without impairing the capability of the land (Mathews 1996).

The principal requirements for a sustained yield of timber are:

1) The soil and growing stock of trees must be kept in healthy and productive condition;
2) The composition, structure, and stocking of each stand must match the capability of the site;
3) The condition of the soil and increment of the growing stock must progressively be improved;
4) The individual stands must be so arranged that they can be tended and harvested efficiently;
5) Appropriate distribution of size and age classes from youth to maturity within each unit of management;
6) To keep reserves such as trees or money or both which are created as security against catastrophy.

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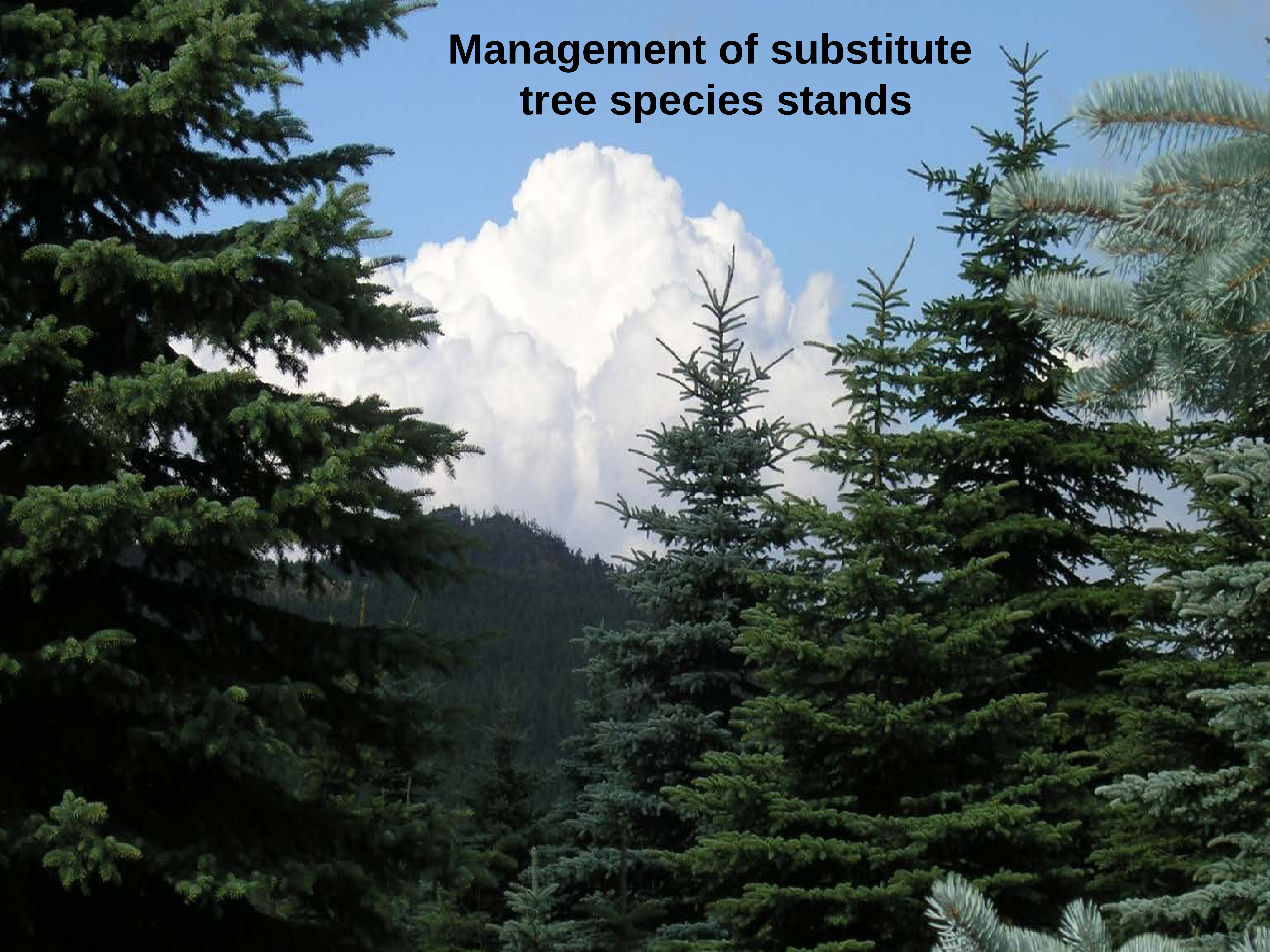
Burley J. et al. (eds.). 2004. Encyclopedia of Forest Sciences. Oxford, Elsevier:

Management of substitute tree species stands



Substitute tree species stands (STSS) were planted in order to maintain forests under heavily air-polluted conditions mostly in 1970s - 1990s. Their establishment was aimed to urgent secure of the most important non-productive functions (chiefly soil protection and hydrological roles).

Area of the substitute species stands is roughly 41,000 ha in the most impacted region of the Krušné hory Mts. (ÚHÚL 2007) and about 5,000 ha in the second heavily affected region of the Jizerské hory Mts. The following species were planted to establish the stands most frequently: *Betula sp., Picea pungens, Larix decidua, Sorbus aucuparia, Pinus rotundata, Pinus mugo, Alnus sp*.

During '90s, industrial emissions were efficiently reduced, and substitute tree species stands are being converted into target species ones, that will optimally fulfill all demands putting on forests. In the presented work we propose conversion methods of STSS. The methods are based on special created classification system and urgency order.

STSS-classification:

1. Stands fulfilling both wood-producing and non-wood-producing functions. Proportion of substitute species does not exceed 30%, and formation of the optimal target species stand can be performed using forest tending practice (thinning).

2. Stands fulfilling non-wood-producing functions only. Soil conditions are disturbed and revitalization measures (e.g. mounds spreading and amelioration) are needed. Stand conversion requires target species planting.

3. Stands fulfilling non-wood-producing functions and partly wood-producing ones. Soil conditions are not seriously disturbed and revitalization measures are not necessary. Stand conversion requires target species planting.

4. Stands neither fulfilling non-wood-producing functions nor wood-producing ones. Unstable stands also in future (e.g. heavily damaged birch stands).

5. Stands fulfilling non-wood-producing functions on extreme sites where wood production is eliminated (e.g. protection forests).

Urgency order of the substitute stands conversion takes into account the following view-points:

threat to forest ecosystems (e.g. soil erosion),

functions fulfillment and losses (chiefly concerning wood production),

suitability of present stands for conversion.

As second row criteria:

air pollution stress, **present wood production** and **converted stands area**.

Proposed conversion measures recommend larger differentiation of silvicultural methods than contemporary common forest practice. Conversion procedures are suggested according to **site conditions** (higher mountain locations, lower mountain locations), **converted stands species composition** (exotic conifers, deciduous species, mountain pine), and **planted species** (shade-bearing species, Norway spruce, pioneer species, mountain pine).

According to our results, the following management schedule differing from the present silvicultural procedures is recommended:

- More detailed differentiation of silvicultural practices in relation to site conditions and traits of planted tree species (tolerance or sensibility to stresses).

- On the higher mountain sites (mountain ridges, tops and mountain plateau), positive effect of the substitute tree species shelter upon frost-stress sensitive target species (e.g. European beech, silver fir) is important and inevitable. Therefore, individuals of these species should be planted close to the substitute species stems i.e. into the crowns. In the lower elevated locations, new plants should be planted within the stand openings and gaps.

Further reading

BALCAR, V. – KACÁLEK, D.: **European beech planted into spruce stands exposed to climatic stresses in mountain areas.** Austrian Journal of Forest Science, 125, 2008, Heft 1, s. 27 – 38.

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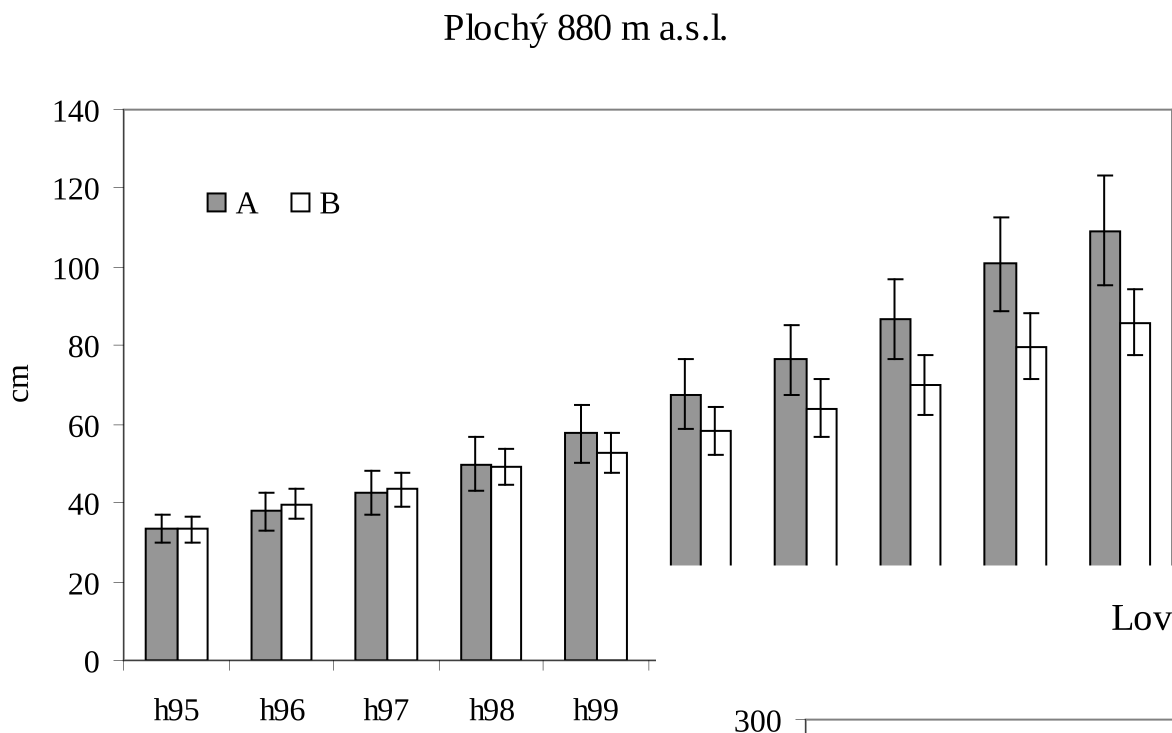
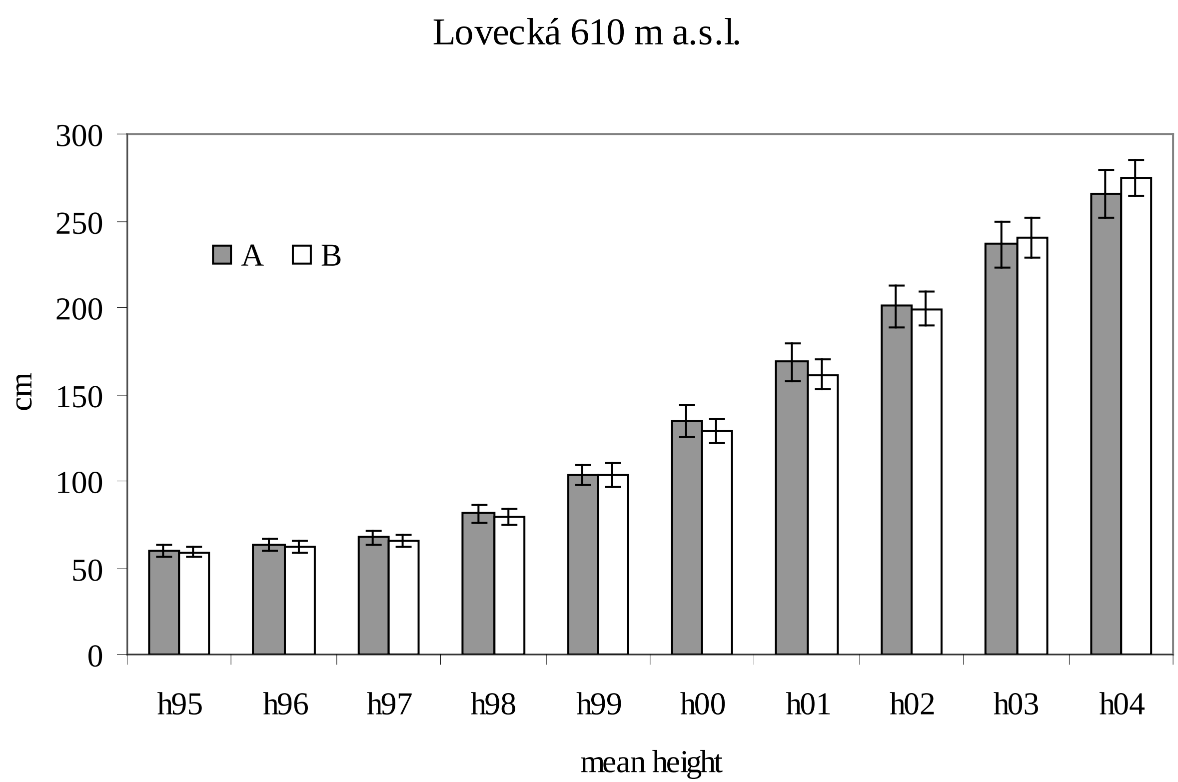
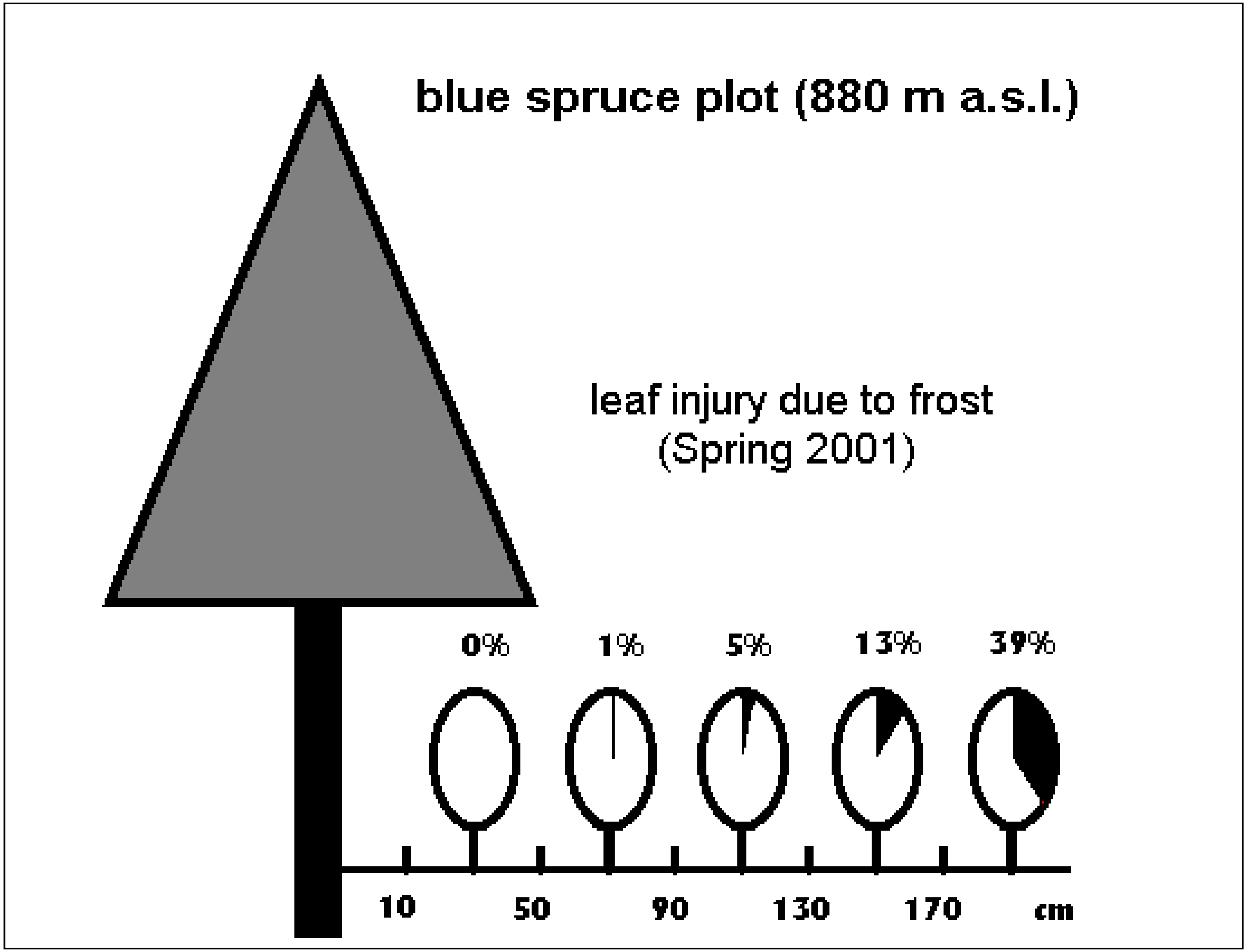


Mean heights of beech plantation in particular years; A (grey columns) represents group of individuals under shelter of substitute blue spruce stand (planted within 90 cm from the stems of spruce), B (blank columns) represents group of beeches planted into the canopy openings and gaps.



Error bars denote confidence intervals at 95% significance level. The sheltered beeches (at higher elevations) proved significantly different mean height compared to individuals in gaps.



Leaf area of beeches damaged due to ground frost; a trend of increasing damage according to distance from sheltering spruce is obvious.

Gap

Shelter

Conversion of mountain stands under ground-frost-affected conditions

Large clearings <u>changed micro-climatic conditions</u> in terms of increased frequency of low minimum temperatures;

Air cooling due to radiation prepared way for occurrence of so called <u>„cold air lakes“ in concave-shaped terrain depressions during night</u>;

This <u>thoroughly altered environment caused difficulties</u> in process of mixed forest stands restoration.

In order to find limits of regeneration under ground-frost-affected conditions, a research plot was established in mountain pine stand situated in shallow mountain valley (860 m above sea level) in 2004.

The experiment encompasses measurement of climatic characteristics and evaluation of tree species (rowan, birch, Norway spruce, mountain pine) prosperity in relation to older mountain pine spacing.

The objective of our study addresses a principal question:

Does sheltering mountain pine help young plantations to cope with conditions of late-frost-affected area?

Contemporary vegetation cover of the research plot is composed mainly of mixed mountain and bog pine (*Pinus mugo, Pinus uncinata*) stand of unknown origin;

Because of nearby situated protected area of peat bog where native mountain pine population grows, the introduced pines are required to be removed in order to avoid risk of breeding;

Moreover there are still rotten spruce stumps present which proved existence of high forest in the past;

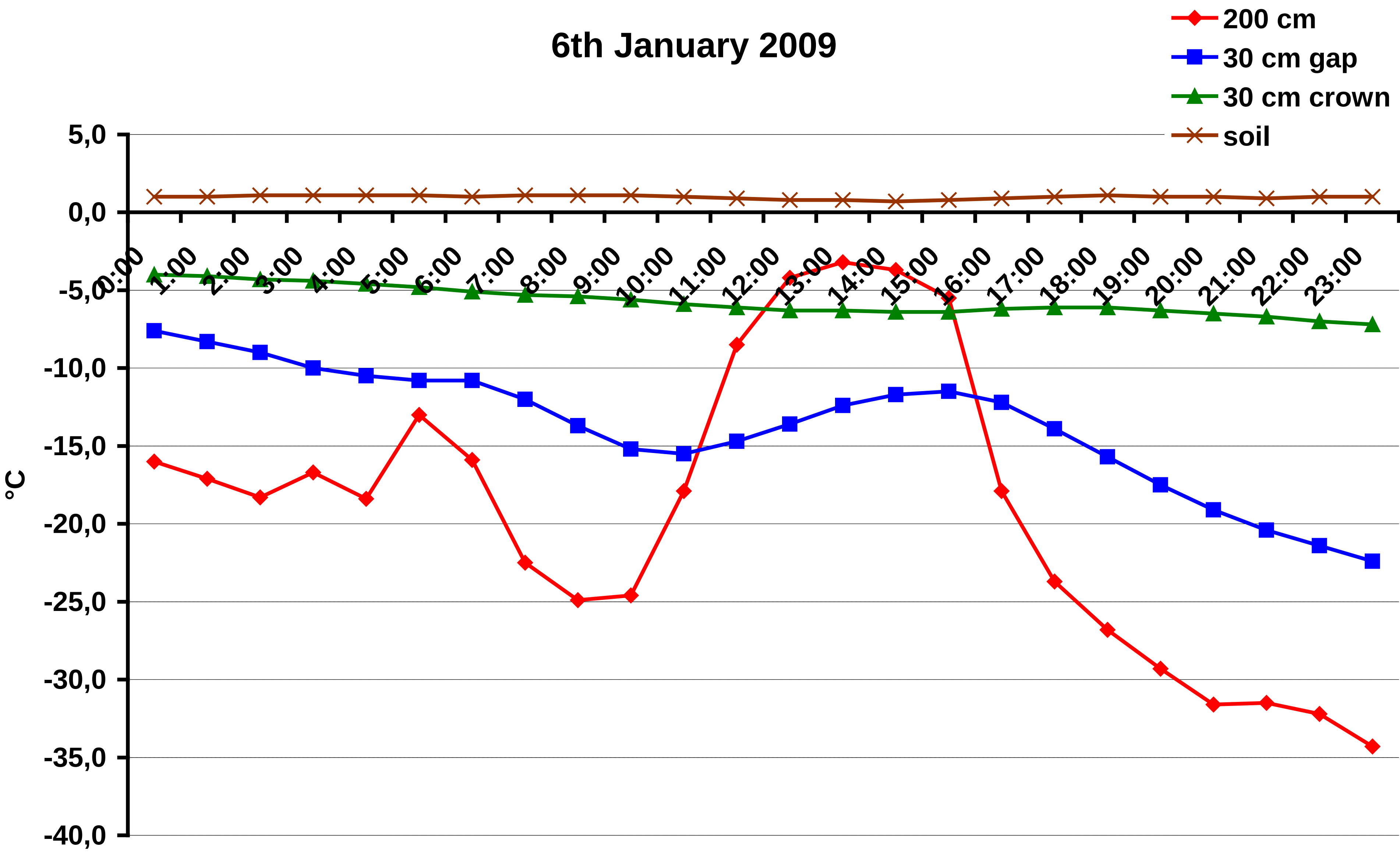
Therefore forest-restoration experiment was established using planting of both broadleaved (birches, rowan) and coniferous (mountain pine, spruce) tree species;

Prosperity of individuals was evaluated according to distance from sheltering pine crown (A – in crown; B – within 90 cm from crown; C – more than 90 cm from crown)

Damage to terminal spruce bud caused by winter frost

Not only late spring frosts influenced young tree species plantations. The terminal bud of spruce exhibited damage also after severe winter 2008 – 2009.

Group A - 13% damage, B - 4% damage and C - 38% damage.



6th January 2009
200 cm
30 cm gap
30 cm crown
soil
°C
5,0
0,0
-5,0
-10,0
-15,0
-20,0
-25,0
-30,0
-35,0
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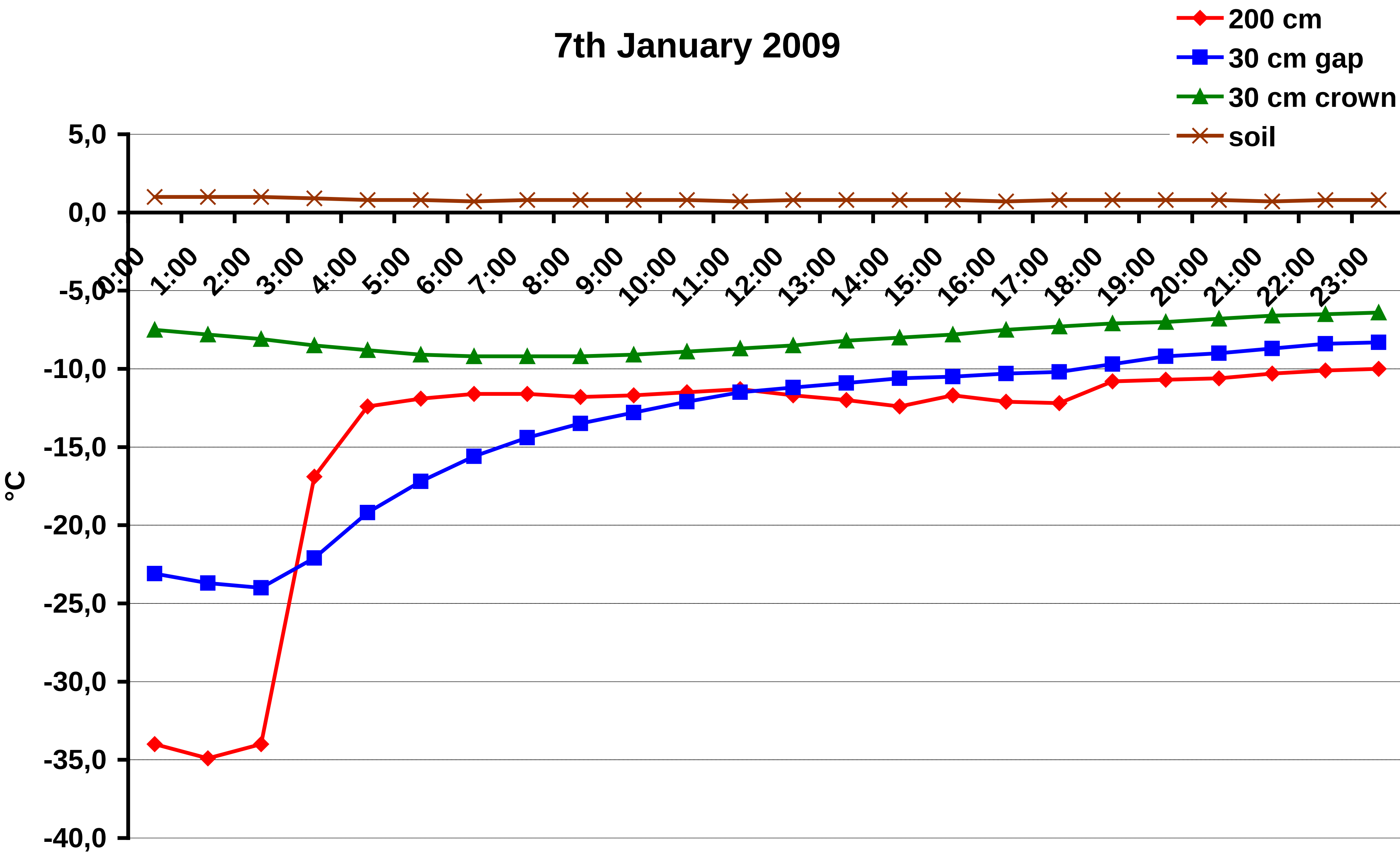

7th January 2009
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30 cm gap
30 cm crown
soil
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-5,0
-10,0
-15,0
-20,0
-25,0
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-35,0
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There are only few woody species that are able to cope with these conditions. Among conifers, both mountain pine (*Pinus mugo* Turra) and bog pine (*Pinus rotundata* Link.) are considered suitable species for these sites.

However, these pines do not provide all demanded services of forest such as production and/or ecological functions. Being able to grow on these sites, the pines provide transplants of the other species with shelter.

This offers us to use a two-step approach. We should plant the site with pines at regular spacing first. As soon as mean height of pines reaches 1 – 1.5 m and canopy closure is at least 60%, we can plant the other tree species such as Norway spruce *(Picea abies* (L.) Karst.*),* Carpathian birch (*Betula carpatica* W.et K*.)* and mountain ash (*Sorbus aucuparia* L.) using containerized planting stock.

Proposals of tree species composition for frost-affected mountain sites are dependent on the type of growing conditions. Both broadleaves (birch and mountain ash) should be planted into groups (10 – 20 individuals).

For the spruce transplants planting, foresters should prefer mounds and elevated places around the stumps for planting and avoid holes and water-logged depressions.

Birch is able to cope with moist places better than mountain ash. Northerly to westerly margins of pine's crowns show milder climatic growing conditions, better for planting Norway spruce, Carpathian birch and mountain ash transplants.

Plantations must be protected from game (fencing) and mice (application of traps with poison is strongly limited in protected areas). If more than 20% of initial number of seedlings dies, additional planting will be needed.

The stands should be thinned in terms of support of species which were planted into the sheltering pines i.e. to remove pine branches impeding prosperity of new plantation and both damaged and dead individuals should be also removed.

There are also areas being protected for nature conservation purposes where non-native populations of mountain pine and bog pine are present. In order to avoid breeding with local populations, the nursing pines should be removed as the crop species overgrow them and the threat of frost damage is over.

Forests on former agricultural land

HISTORY OF AFFORESTATION FROM THE MIDDLE-EUROPEAN POINT OF VIEW

Since the Ice Age, many tree and shrub species altered a species composition of forests which depended on particular environmental conditions.

However the most important agent influencing a development of vegetation cover is a human society.

Even the first Neolithic farmers were likely to create a “cultural landscape” due to deforestation, growing crop plants and breeding farm animals; as for the Middle Europe that process began 7,000 years ago.

Although large areas were made treeless, forests often returned naturally as people abandoned depleted sites.

Afforestation is a principal measure to establish a new forest on land which has never been covered with forest or that one being deforested a long time ago and then used for other human purposes (agriculture).

First records from Classical world mention our lands as inaccessible due to horrible woods and swamps. These large forests lying along borders of the Czech lands were kept undisturbed till the beginning of medieval colonization.

Then both the aristocracy and the clergy including their peasants were allowed to clear the forests to obtain an agricultural land.

At the beginning of the modern era some areas were found so treeless that first afforestations were done to provide people with both fuel and timber.

However a plan-based forest management emerges along with the first Austro-Hungarian laws only at the beginning of the 18th century.

Very large areas were afforested within confiscated land after the World War II.

The total forest land has been increasing till these days. Both Czech government and the European Union support land use change in terms of providing subsidies for afforestation of less-productive agricultural land.

Further reading:

Wiliams M., 2000. Dark ages and dark areas: global deforestation in the deep past. Journal of Historical Geography 26, 28-46.

Wood production of forests on formerly agricultural land

It is a specific process because the stands represent the first-generation forest on sites experiencing a different land use before afforestation.

Regardless of tree species composition, the first-generation forest is a pioneer stage in process of forest environment restoration.

The species composition plays the important role in terms of the amount of biomass accumulated in trees over time.

Standing crop and dimensions achieved by particular tree species are important for exploitability of timber assortments.

To make financial savings on established new stand, fast-growing tree species can be planted creating an important share in tree species composition over a period of time.

Example from the experimental plot:

Larch was a dominating species in the 8-year-old plantation. This species shared 48% of total basal area.

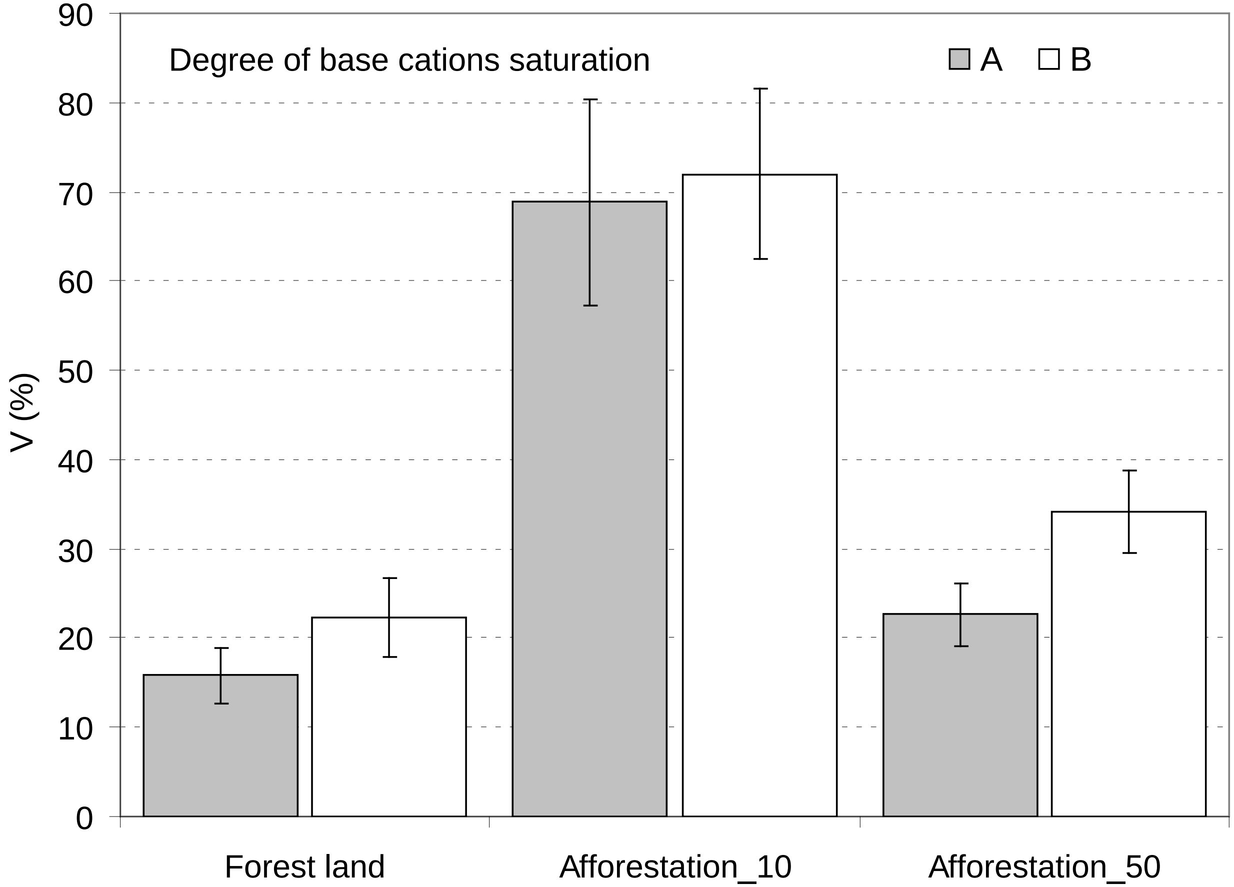
Beech did not perform well sharing only 1% of basal area.

The dry-biomass amount of larch (25.8 $Mg.ha^{-1}$) exceeded both the spruce (5.8 $Mg.ha^{-1}$) and Douglas fir (18.0 $Mg.ha^{-1}$).

Mean DBH of the conifers was as follows: larch – 10.8 cm, Douglas fir – 7.9 cm and spruce – 5.5 cm.

It could be concluded that larch provided merchantable fuel wood from the first thinning. Conifers were generally more productive species compared to broadleaves in the juvenile-stage forest.

Soil properties of afforested former agricultural land



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Uneven-aged management vs. even-aged management

Uneven-aged silviculture may be defined as the tending and regeneration of forests which contain trees of several age classes in intimate mixture (Halliwell 2004 ex Burley J. et al. (eds.). 2004. Encyclopedia of Forest Sciences).

From strict point of view, this management approach includes only selection or group-selection systems.

Broadly understood definition allows to include stands of trees with only two or three age classes such as coppice with standards or even-aged crops that have been underplanted with younger trees. However these are still closer to regular even-aged crops and should be considered a first stage towards a truly multi-aged stands.

The essential difference between even-aged and uneven-aged silviculture is that the uneven-aged approach does not take any direct account of the age of the trees or the area which is occupied by each age class.

Silvicultural systems

Uneven-aged management	**Even-aged management**
Selection system, Group-selection system	Shelterwood system, Clear-cutting system
	Coppice system

No single system is ideal for all situations!

Factors governing the choice of a silvicultural system are as follows:

- The reproductive requirements and habits of the desired tree species;
- The site conditions;
- Constraints and requirements imposed by wildlife;
- Problems arising from insect pests, fungal diseases, fire or climatic hazards;
- The size, age, and vigour of existing trees;
- The introduction of new species or improvement of genetic composition of a stand requires planting and even-aged system;
- The social constraints such as manpower, money, equipment and market.

Silviculturists decisions are based on understanding the processes affecting each development stage and the structure of forest.

This knowledge allows silviculturists to predict the development pathways that each stand could take in the future.

The desired status of a stand can be achieved using silvicultural operations as surrogates for natural processes such as disturbances and regeneration.

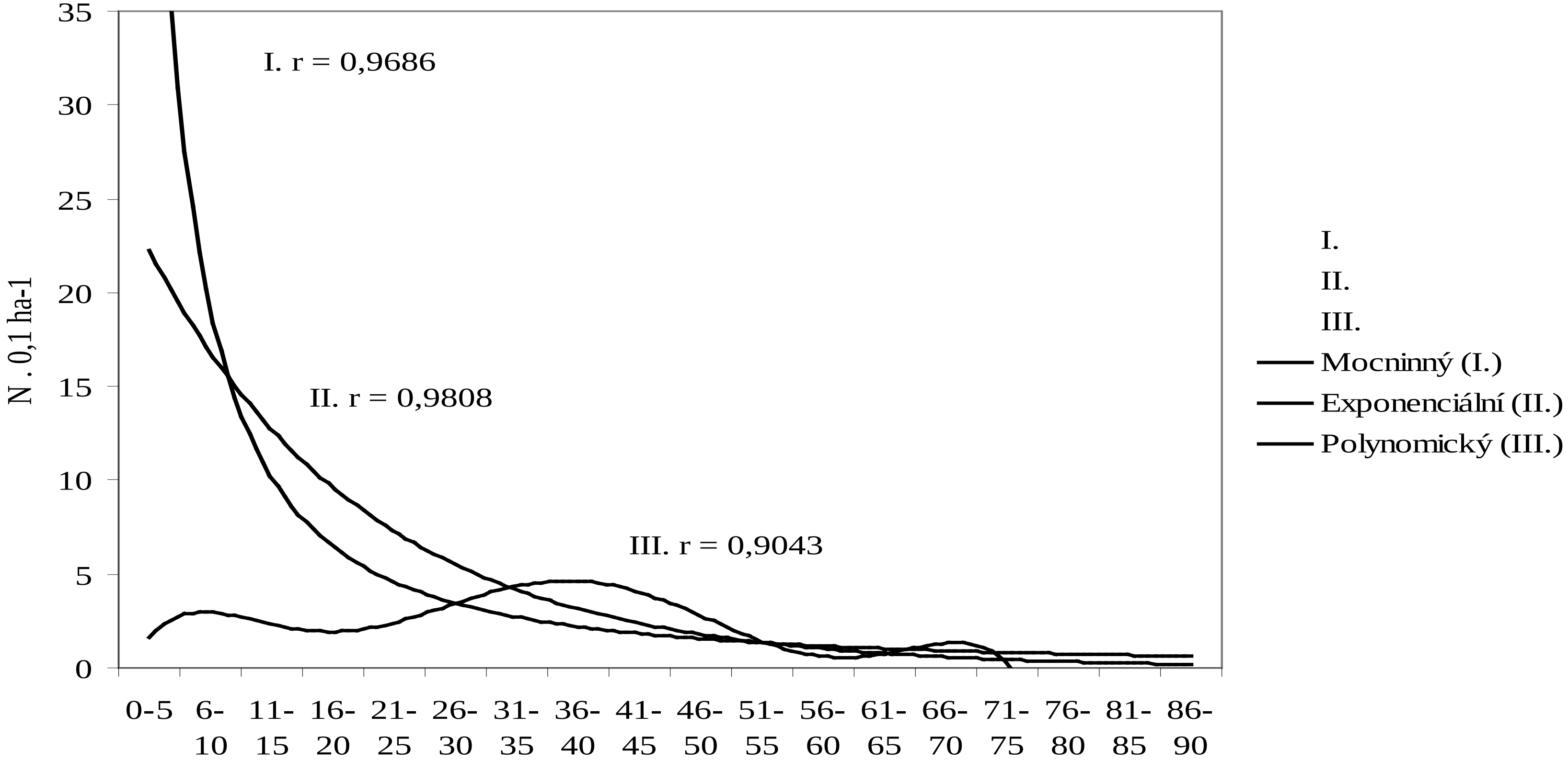
An appropriate silvicultural operation can be prescribed by understanding how the stand will respond.

There are also tasks related to nature conservation. Uneven-aged silviculture may not provide suitable conditions for species that prefer clear-felled areas.

If all the forest within large areas of land is managed in uneven-aged way it may be necessary to have some clear-felled areas in order to allow such species to survive.

On the other hand, the silviculturist can provide some species with suitable habitat in trees which are left to grow to senesce.

The greater structural complexity of uneven-aged forest provides a greater variety of ecological niches at a local scale than do even-aged stands.



DBH-structural patterns based on DBH cluster analysis; roman numerals express different pattern curves (I – power trend; II – exponential trend; III – polynomial trend; the value of r ≥ 0.9 proves satisfactory approximation. X axis – diameter class; Y axis – number of individuals per 0.1 ha.

The growing stock of uneven-aged forests tends to follow a negative exponential curve, when number of trees are plotted against their stem diameters (Halliwell 2004 ex Burley J. et al. (eds.). 2004. Encyclopedia of Forest Sciences). On the other hand, the even-aged or optimum-stage forest tends to show a typical bell-shaped curve.

The structural patterns of DBH distributions are likely to play similar role in the near-natural mixed stands, however indigenous forests are the only ones where particular stages of development are to be found. Furthermore the real development stages create various mosaic within the stands (Míchal, Petříček et al. 1999).

Either knowledge of management history or absence of management are important factors to characterize development of stands. For example, a selective structure within non-managed stand can not be considered a selective forest since the structure does not result from forester‘s decision but it is a selective phase that is a transitive period between the recruitment and disintegration stages (Korpeľ et al. 1991).

Even though the selective cutting is being considered more near-natural measure to manage forest stands, the demanded structure have to be kept via relatively intensive management. However all stands studied belong to especially protected preservations where the intensive measures are to be avoided. The absence of selective cutting leads to canopy restoration and subsequent difficulties with natural regeneration (Saniga 2000).

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Thank you for your attention