North European Platyphyllous Forests: Biodiversity Dynamics and Climate Changes in Northwest European Russia

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Distribution, biodiversity and reforestation dynamics of the platyphyllous forests in the Northwest European Russia were investigated. Data assembled from 21 landscape regions (250–350 sq. km each) show special features of small-leaved lime, Norway maple, mountain elm and English oak reforestation during the last two decades.

New tendencies were found for the taiga areas with natural Norway spruce and Scots pine vegetation. Natural platyphyllous reforestation in cut spruce areas poses as supposed a special question for forest management policy in the relationship to global climate changes. Feasible unsustainability of the common types of succession (Norway spruce – European birch; Norway spruce – European aspen) is discussed.

Biodiversity of herbs, shrubs and tree species of platyphyllous forests is high and complex and is situated in 4–15 oldgrowth relics in each landscape region. Low level genotype heterogeneity of nemoral flora species of such isolated populations is presumed. Special biodiversity conservation regulations are proposed.

Keywords European platyphyllous forests, biodiversity, climate and reforestation.
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1 North European Platyphyllous Forests

Platyphyllous, or nemoral broad-leaved, forests form an extensive band in temperate Europe between Atlantic Ocean and Ural Mountains. Moreover, mountain elm *(Ulmus glabra* Huds.), English oak *(Quercus robur* L.) and some other platyphyllous tree species dominate or codominate in plant communities in the boreal North and Northeast Europe (Kurnaev 1968, 1980, Popadjuk et al. 1994).

Floristic composition of the platyphyllous vegetation includes a number of species which are known by a particular origin as a nemoral floristic element (or the tertiary flora of the South East Asia). Relic nemoral flora communities with their structure and biodiversity richness are opposing to taiga forests monodominancy in the boreal regions of Europe and Asia (Sochava 1946, Tolmachev 1954).

Such platyphyllous forest communities in the boreal areas of Europe will be named below as North European platyphyllous forests in a contraposition to temperate regions broad-leaved arboreal vegetation. Some ecological reasons on this opportunity were demonstrated by some authors, for example, when the "dark platyphyllous forests" type was singled out (Kurnaev 1980).

Meanwhile platyphyllous forest communities are sufficiently investigated in temperate regions of Russia, there are no complete data for boreal (or taiga) regions (climatic and vegetation zoning according to: Aleksandrova et al. 1989). The aim of this work is to summarize extensive field research results and some odd data on holocene history of and human impact on, structure and dynamics of platyphyllous forest vegetation in Northwest Russia.

Biodiversity dynamics in connections with forest structure succession is a special interest of this paper. Natural climatic changes were the main factor of biodiversity changes during the Holocene. Composition of the nemoral and the boreal floristic elements (including trees, shrubs and herbs species) was a product of successions related with long-term distribution areas increasing process.

Both climatic affect of the Little Ice period and extensive human activity forced out the nemoral flora from plains to river valleys and calciferous areas (Zinzerling 1932). Platyphyllous forests were subplanted by Norway spruce and preserved only in some localities. Present situation demonstrates a reverse process when the nemoral flora species become the important part of forest composition.

2 Platyphyllous Forests in Northwest European Russia

The Northwest European Russia region is a Baltic Sea basin territory between Ladoga Lake and Finland in the north and Daugava River (Belorussia) valley in the south. Land square of the region is more than 150 thousand sq. km around Saint-Petersburg city. Plain country with some moraine hills (not over 300 m above sea level) is covered by boreal taiga forests: with Scots pine *(Pinus sylvestris* L.*)* on sand soils and Norway spruce *(Picea abies* (L.) Karst.*)* on clay soils. Anthropogenous vegetation on cut areas is represented by self-sown European birch *(Betula pubescens* Ehrh., or widely distributed hybrid races *B. pubescens x B. pendula* Roth*)* and European aspen *(Populus tremula* L.*)* (Nitzenko 1958).

Fig. 1 presents boreal (taiga) vegetation zoning for Northwest Russia (Aleksandrova et al. 1989) where north (1), middle (2), south (3) and subtaiga (4) subzones are shaped. Some authors (Kurnaev 1968) name subtaiga subzone as mixed coniferous-platyphyllous forests and suppose that it is not boreal, but temperate climate vegetation. The boundary between the middle and the south taiga subzones in Northwest Russia is in compliance with the limit between the south boreal and hemiboreal subzones according to Hamet-Ahti (1976). Typical landscape areas investigated in this research are marked (black areas) in Fig. 1 too.

Platyphyllous forests distribute sporadically in Northwest European Russia now, where they were cut extensively during years 1700–1950, especially for small-leaved lime *(Tilia cordata* Mill.*)* wood products. Therefore, in South Sweden platyphyllous forests are more typical vegetation and some points for South Finland are checked (Kalela 1961, Bjornstad 1971, Kielland-Lund 1981, Korotkov 1991).

2.1 Holocene Vegetation History

Holocene vegetation history of Northwest European Russia includes a warm, temperate and moist period between 6.5–5.5 thousand years ago (Neishtadt 1957). During this time the most part

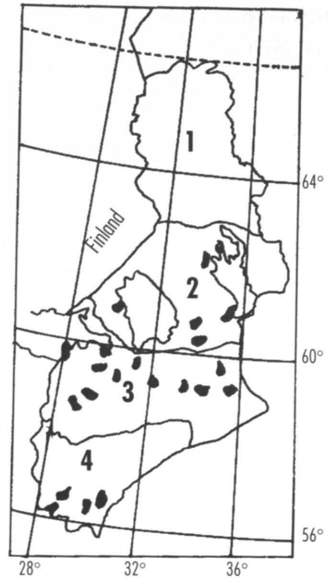

Fig. 1. Northwest Russia vegetation zoning (Aleksandrova et al. 1989) and landscape areas investigated. (Zones: north (1), middle (2), south (3) and subtaiga (4), typical landscape areas investigated in this research (black areas)).

of the region was covered by English oak, small-leaved lime and mixed European birch – small-leaved lime forests on clay soils as well as Scots pine and mixed pine-platyphyllous communities occupied sandy habitats (Nitzenko 1955).

Near 6.0 thousand years ago the northern boundary of English oak distribution area was limited by the south shoreline of White Sea (latitude 65) that is more than 500 km north from present habitats. Similar distribution was peculiar characteristic to small-leaved lime, mountain elm, European elm *(Ulmus laevis* Pall.*)*, European ash *(Fraxinus excelsior* L.*)* and Norway maple *(Acer platanoides* L.*)*. Even European beech *(Fagus sylvatica* L.*)* is known from pollen deposits of Northwest European Russia (Neishtadt 1957).

Middle Holocene was continued by a period with humid climate and unstable temperature conditions when Norway spruce area was increasing. Norway spruce became to the Northwest European Russia near 5.0–4.5 thousand years ago as second layer tree in platyphyllous forests (Nitzenko 1955, Minyaev 1966). Pollen data on Norway spruce distribution have some contradictions. The natural areal increasing process was very gradual and only almost 2.0 thousand years ago this tree species was spread to the northwestern part of the region – to Karelian Isthmus (Malyasova et al. 1965). Other point of view show not "south-to-north" but "east-to-west" Norway spruce coming (Tallantire 1972, Elina 1981). Last authors mark distribution boundaries near Petrozavodsk (Karelia) 7.5 thousand years ago and near Helsinki 3.5 thousand years ago.

In other way, unstable temperature conditions were provoking platyphyllous forests depression during the last few thousand years. Cold winter temperatures of boreal climate were marked with English oak, European ash and mountain elm areals decreasing. Norway spruce succession in platyphyllous forests changed soil acidity and light conditions and flora of the nemoral shrubs and grasses was migrating into intrazonal habitats. As a result the dark coniferous taiga with Norway spruce became dominance type of vegetation in the region of Northwest European Russia.

2.2 Human Impact

The present distribution of platyphyllous tree species and forests in the Northwest European Russia is connected with two main factors: (1) the past climate changes described above and (2) the human activity.

The density of human population passed two maximums in the rural areas in the regions similar to the Northwest European Russia. First maximum was checked between 11th and 14th centuries when traditional slush and burn agriculture was effective on the basic of climatic conditions. Then The Little Ice Period began and both the cold climate and historic tendencies induced immigration to towns and to the Central European Russia. Second maximum was embracing 18th–19th centuries and strengthened by the construction of St.Petersburg city and the redevelopment of neighboring areas.

The human impact had relations to the existence of platyphyllous forests. Historically English oak and small-leaved lime vegetation had occupied the most fertile soils in Northwest European Russia. Such areas were first involved in agricultural development, and the land annals demonstrate that in 19th century the agriculture regions were took place on special "poddubitsy" (i.e. "oak forest soils") soil type (Zinzerling 1932).

Mature oldgrowth English oak forests were cut extensively for construction and shipbuilding purposes and young small-leaved lime forests – for footwear handicrafts. Footwear handicraft alone was consuming more than 2 thousand sq. km of lime forests per year in the European part of Russia during the 19th century (Kurnaev 1980).

In the 20th century, active migration processes followed by industrial development and organization centers in connection with railroad network became the main cause of the changes in rural regions. Old, 19th century agricultural regions were neglected, and at the same time some of the 19th century forest regions were turned into account of agriculture and cutting areas. So, in 20th century the most important human impact to platyphyllous forests is ordinary forest management with extensive cutting processes.

2.3 Present Distribution

Traditionally, Russian geobotany and forestry interpret platyphyllous forests in the taiga zone as intrazonal habitats vegetation type (Zinzerling 1932, Porfiriev 1970, Lavrenko 1980, Korotkov 1991). Calcareous and alluvial valley soils and river valley microclimate conditions are named as a leading factor of modern platyphyllous forests distribution. Such an approach also includes an idea of English oak monodominant position in East European platyphyllous forests (Nitzenko 1958, Popadjuk et al. 1994).

Some authors (Kurnaev 1968, 1973, 1980) suppose that in the natural platyphyllous forests English oak grew as monodominant tree species in steppe and forest-steppe vegetation of temperate zone, but small-leaved lime and mountain elm codominance in boreal taiga regions. In this way, English oak boreal taiga forests have an anthropogenous nature of origin caused by pasture and cutting. Mixed lime – elm – European maple – European ash vegetation named as "dark platyphyllous forest" in opportunity to "light platyphyllous forest" with monodominant English oak.

The most recent areal maps (Hulten and Fries 1986, Bubyreva 1992) show northern limit of modern distribution for small-leaved lime and European maple near the south coast of the White Sea; for both, mountain and European, ash near the north coast of Onega Lake (Central Karelia); for English oak and European ash the south shoreline of Ladoga Lake (and South Finland for English oak too). So, all East European tree species have distribution inside the whole territory or main part of the Northwest European Russia.

3 Materials and Methods

The Northwest European Russia is divided into 70–80 landscape areas with special climatic and geomorphologic features. Previous data consider that only near 15–35 points of each platyphyllous tree species were known for near 150 thousand sq. km. And in most cases platyphyllous trees were found only as shrub form or second layer stand.

Special investigation was begun in 1991 and as a result 21 landscape regions of the Northwest European Russia (see Fig. 1) were inspected (250–350 sq. km each) in different climatic subzones (from middle taiga in Karelia to mixed coniferous-platyphyllous forests subzone in the south, near the Belorussian border).

Primary landscape analysis based on detail map and description data was given for every landscape region to indicate 'hot spots' points before field research. Also, herbarium samples data were taken into account for preliminary delimitation of concrete area of investigation.

Field research included two stages: (1) preliminary route inspection of the area, and (2) detailed investigation of platyphyllous and related forest communities.

The preliminary inspection of the area supposed common vegetation cover description, human impact analysis for forest areas (forestry activity evaluation, main sources of air pollution determination, analysis of the past and the present agricultural influence to forests, *etc.*), detailed geomorphological analysis. Concrete localisations of platyphyllous and related forest communities could be given only during the preliminary inspection too, in causes that this type of vegetation is not marked on the forest maps for Northwest Russia.

The detailed investigation stage is based on forest analysis made in accordance to Sukachev approach of dominance-oriented classification of vegetation cover (Ipatov et al. 1995) with some additional components from landscape and biodiversity analysis. Vegetation is described on 400 sq. m samples in large forest areas or in the limits of concrete small homogenous contour (200–800 sq. m).

Description includes trees height (average and maximal for every canopy level and every species), stand volume (could be transferred into biomass) measurement, underwood or shrub evaluation, age analysis and taxation. Moss, herbs and semishrubs abundance and coverage (average for every spot of mosaic and for the whole contour) are estimated. Total square of each type of moss, lichens and herbs cover patch is measured and complete species composition is determinated. Soil typification is given for every type of cover patchs. Special geomorphological description is accomplised for the landscape element where the interesting community is situated.

Completely, more than 240 communities were described and were involved into further analysis. Common classification scheme are based on dominant approach, but also communities were subdivided into groups related for the specific landscape elements (river valleys, plains or hills slopes vegetation, vegetation on calciferous and non-calciferous rocks, on sand, clay or semiclay soils, on moraine, abrasive, accumulative or maritime sediments, *etc.*). Detailed distribution maps for the every nemoral species which was found in the communities and for the every type (dominant association) of communities were given.

As it was ascertained the biodiversity of platyphyllous forests herbs, shrubs and trees species is high and complex and situated in 4–15 oldgrowth relics subregions in each landscape region between Norway spruce, Scots pine and anthropogenous European aspen or European birch vegetation. There are no strong interrelations between calcareous soils and platyphyllous forests habitats. Plain habitats frequency is similar or equal to frequency of river valley forests. There are no differences in square frequency of platyphyllous trees species between middle taiga, south taiga and mixed coniferous-platyphyllous forests subzones, but anthropogenous influence and agriculture history are playing an important role.

4 Structure and Dynamics

Both in plain and valley sites small-leaved lime and mountain elm are forming nearly 20 m high first storey in oldgrowth forests. In some points middle-aged English oak, European elm and European ash cover were found. There are no European maple upper layer stands. In common case, 2–3 platyphyllous tree species are participating in community cover as well as 1–2–3 another tree species. Also mixed coniferous-platyphyllous stands are represented, especially with Norway spruce, and with Scots pine in rare cases. Anthropogenous mixed European aspen – English oak (or small-leaved lime) vegetation is common case than pure platyphyllous vegetation.

The variety in structure is caused by the dynamics variety and represents a row degree of platyphyllous forests succession from communities dominanted by Norway spruce to platyphyllous communities. Local distribution anomalies of some species caused mostly by human impact and geochemical heterogeneity of the area have significance too. Three examples of the forest structure demonstrated below are grouped in order of supposed succession direction.

4.1 Mixed Coniferous-Platyphyllous Forests

Mixed coniferous-platyphyllous stands represent Norway spruce formation in the majority of cases, but Scots pine formation exists sometimes. Ordinary community is dominated by Norway spruce dominance with 20–25 m high and 80–150 years old trees. In many habitats Norway spruce is forming pure upper storey, but one part of the points shows mixed Norway spruce – European aspen stands as a result of small-area selective cutting of the beginning of the 20th century. In fact both species could be predominant, but the biomass of European aspen is lower usually.

Platyphyllous tree species are situated at lower layer in communities described above. Small-leaved lime and mountain ash live successfully under the cover of the upper level of Norway spruce branches. Broad-leaved trees have a wide amplitude of age and biomass in stands between 12 and 19–20 m high. The age of some trees is very difficult to estimate because of different productivity (high – in most cases and very low – in others) and of the possible continuos prefertile period. Shrubs forms of *Tilia cordata* were registered in some landscape regions and in addition coppice shoots trees (even 120–150 years old shoot groups).

Communities which were investigated show a variety of seminatural self-sown secondary coniferous-platyphyllous forests distributed on areas which were cut in 1850–1940 years. Norway spruce vegetation is primary in the Northwest European Russia excluding some taiga greenmoss habitats. Semi-natural forests successions are near primary successions in some landscape regions and habitats with low post-cutting anthropogenous influence. A great number of coniferous-platyphyllous forests were found in areas where direct human pressure was discontinued after the cutting.

4.2 Mixed Aspen-Platyphyllous Forests

The second stage of succession is affected by clearcutting of coniferous-platyphyllous forests. Clearcutting was followed with an agricultural development in cutting areas and did not occupy large area before 1910. After that, in 1920–1970, clearcutting was the main path of forest harvesting and most part of the area in the process became self-sown semi-natural communities.

In most cases the European aspen became the first after-cutting dominant tree species. Somewhere (more often – in peat-forests and on low productivity soils) European birch formed first layer woodstands too. Really, in both situations platyphyllous trees species are playing a similar role, but aspen-platyphyllous forests have a spreading in all landscape regions.

At the age of 40–60 (70) years the aspen-platyphyllous forests should be divided into two groups. Group 1 includes communities with first storey of aspen (monodominancy, 18–23 m high) and low second layer of seed or(and) coppice shoots trees of small-leaved lime or seed European maple stands (11–12 m high). In such communities platyphyllous thicket is changing light and soil conditions in a wide scale, but only broad-leaved trees wood will be including the only 15–30 per cents of whole biomass. And only after new clearcutting a possibility of platyphyllous dominance will be a question of the day.

More rare and more interest picture is shown for Group 2, where platyphyllous and aspen stands have equal age. European aspen is growing better and more quickly in the first period of reforestation and is forming an upper layer. After age 20–30 English oak and small-leaved lime have more preferable conditions for growth under the aspen cover (in reasons on winter minimum temperature adaptation in undergrowth microclimate conditions). Moreover, after age 40 platyphyllous second layer stands begin to consolidate into the upper, aspen storey. This process of platyphyllous tree penetration into the upper layer is a probable way of final stage succession.

4.3 Platyphyllous Forests

The third and the final type of communities have two sources of origin. First, some oldgrowth relic platyphyllous forests are locating in a number of landscape regions. These primary, wild forests were found on both clay and sand planes and valley terraces. Primary forests are populated by mountain elm, English oak, small-leaved lime everywhere and by European ash in only 1 location. Monodominant stands are more typical for European ash and English oak communities. Mountain elm is growing in some cases as codominant with small-leaved lime and in other locations as monodominant.

Relic oldgrowth communities are represented not only by primary forests, but also by platyphyllous forests gap-mosaic successions stages. Primary forests with stands of one age group have the upper layer 14–17 m high in middle taiga subzone landscape regions and 18–21 m high in south taiga subzone. Similar data were obtained for gap-mosaic succession stages, but the first storey is lower in some points. In some places original lime-tree stands were cut more than a century ago, but trees of coppice shoot origin form the upper storey 20 m high now.

Platyphyllous vegetation with another source of origin is more significant for dynamics investigation. Some communities were observed where the dominance of platyphyllous tree species is a result of aspen-platyphyllous forests succession. There is only probable succession in common case, but some examples of the habitats demonstrate a real row of variants of communities in which aspen dominance decrease gradually as well as small-leaved lime, mountain elm or English oak biomass and importance grow up.

Similar secondary platyphyllous forests are represented by mixed *Ulmus glabra – Tilia cordata* communities in valley habitats and *Quercus robur – Tilia cordata* stands on plains. Average age of dominant tree species is near 40–60 years and the upper layer resulted is near 18–22 m high. Some exclusions were shown for the middle taiga regions in which small-leaved lime or European maples occupy clear-cut areas of Norway spruce areas as monodominant tree species. But succession history was limited by 10–15 years in all such cases.

5 Climate Changes Impact

Climate dynamics and human activity were the main factors in spreading of platyphyllous species and forests in past. Although its climate changes impact is well known, but was described only as long-term influence affect. Mainly macroclimatic changes with 100–1000 duration cycles were investigated and the species composition of communities only was shown as a result of interrelations between climate conditions, their changes and vegetation history.

Present and future climatic changes are supposedly occurring more quickly and their results should be more intensive. Especially short-term vegetation structure and composition changes are playing significant role for the forestry and the biodiversity preservation. In this matter 10–100 years forest succession cycles stability under the climate changes influence become a most important part of the boreal taiga sustainability. And specific changes in the modern short-term successions effected both by continuous climate changes and catastrophically fluctuations could be demonstrate probable future forest succession paths.

5.1 Succession Type Unsustainability

Climate dynamics is a leading factor of small-leaved lime and mountain elm reforestation now, as were shown during investigations in 21 landscape regions of the Northwest European Russia (Chtchoukine 1995). Average year temperature is growing in some parts of the territory during the last two decades. A great number of new young platyphyllous growth was found (between 8–45 examples per landscape region). Data show that only last 10–15 years give a new basic tendency – platyphyllous (not aspen and birch) reforestation in cut spruce areas. This type of succession is common now not only in the mixed platyphyllous-coniferous forests climatic zone, but also in the south and the middle taiga subzones (even in Central Karelia).

In favorable climatic conditions similar type of vegetation succession could be common in extensive areas of the Northwest European Russia and, probably, in the southern Scandinavia. Warmer climate also gives more possibilities for aspen-platyphyllous communities succession into pure platyphyllous forests. Potential vegetation of the region (or for a part of its, especially for plain habitats on clay soils) should be platyphyllous forests with 2 or 3 broad-leaved species codominance.

Two kinds of unsustainability may be possible due to climatic changes in the future in the connections with platyphyllous vegetation existence in the boreal zone of the North Europe. Both will be affected by modern biodiversity unsustainability and the structure of succession cycles redevelopment caused by warmer climate.

At first, coniferous (mainly, Norway spruce) self-sown on cut areas will be suppressed under more competitive platyphyllous forests succession type. There is a question which type of succession (through aspen to Norway spruce or through aspen to broad-leaved wood species) is more competitive in natural, gap-mosaic successions, but clear-cut territories give more chances for small-leaved lime and mountain elm in the Northwest European Russia. Concrete way of the processes of climatic changes could be resulted in more fast or slow Norway spruce type of succession depression. In these reasons, detailed mosaic of microclimates and habitats should be a main factor of succession type differences.

Another succession unsustainability source is placed in the population structure of platyphyllous tree species in the North Europe. Small-leaved lime, English oak, mountain elm and other nemoral tree species were growing in Northwest European Russia and neighbored countries in isolated populations during some decades or, may be, centuries. Moreover, previous data give an information that small-leaved lime had not have seed reproduction during the first half of 20th century and only vegetative, coppice shoots trees populations are presented now.

In this matter, modern situation suggests a low level genotype heterogeneity in each landscape region or habitat and high level heterogeneity of populations from different landscape regions. Main problem in this case is a great unsustainability of such isolated populations and their posterity during climate changes and fluctuations. Platyphyllous stands followed from new types of succession cannot be more stable than primary Norway spruce vegetation. More detailed modelling for this purposes is needed, but first suggestions conclude that special genotype management for platyphyllous forests sylvicultures and wild genotypes resources investigation and attraction are requested. In this way Ural Mountains platyphyllous tree species populations which are existing in more continental conditions could be used as genotype source, for example.

5.2 Dark Coniferous Taiga Biodiversity

Probable process of Norway spruce type of succession depression which will be subject of few next decades according to modern climate change effect and clear-cut forestry technique if forests are left to regenerate naturally provokes new biodiversity threat for some boreal regions.

Dark coniferous forests species include a natural group of grasses and semi-shrubs adapted to cold climate, acid soils and low light density conditions of boreal vegetation. Part of such species has not have chances for an adaptation to more warm climate, to high light density and sand, poor water soils of Scots pine forests or to more neutral and alkaline leaf fall of platyphyllous trees.

In the new situation some species will be suppressed and become extinct in the most part of their European areals after the platyphyllous type of succession establishment caused by climate changes. Three ways of suppression are supposed:

- *particular* – when species has more wide habitats distribution and will be preserved in another, non Norway spruce communities *(Vaccinium myrtillus* L., *Neottia nidus-avis* (L.) L.C.Rich, *Solidago virgaurea* L., *etc..);*
- *direct* – when species will be depressed by only climatic conditions changes *(Aconitum septentrionale* Koelle, *Rubus arcticus* L., *etc..);*
- indirect – when species will be avoided by the platyphyllous type of succession influence not by direct climatic conditions effects *(Pyrola media* Sw., *P. rotundifolia* L., *Epipogium aphyllum* (F.W.Schmidt) Sw., *etc..).*

Afterwards, dark coniferous forests biodiversity preservation is needed in connections of future climate and vegetation changes in regions with modern south and middle taiga climatic subzones. Mainly whole habitats of Norway spruce oldgrowth forests with complex boreal biodiversity should be preserved and habitats of dark taiga herbs and semi-shrubs threatened by indirect suppression should be retained too.

5.3 Nemoral Flora Biodiversity

It could be strange, but nemoral flora biodiversity will be under the threat particularly too. A leading factor of such phenomenon is not future climate changes itself, but modern status of nemoral flora species populations and local biodiversity.

The biodiversity of the nemoral flora (i.e. flora of platyphyllous forests) in the Northwest European Russia is like giant broken mirror pieces dispersed between boreal taiga foreground. Only 2 cases from 21 landscape regions show a complete nemoral flora list with near 50 species of trees, shrubs and grasses. In other cases only part of species is presented, near 20–30 nemoral flora species in a common case.

Situation described before calls a necessity to make special preservation measures for each old-growth or significant biodiversity level platyphyllous forests communities and for post-platyphyllous nemoral flora (where broad-leaved trees stands were cut, but nemoral herbs and shrubs biodiversity is presented) forests too. Some grass species which have a modern spreading only in limited number of locations should have special regulations (for example, *Sanicula europaea* L., *Mycelis muralis* (L.) Dumort., *Mercurialis perennis* L., *etc..*).

Such measures are necessary, because a modern low genotype heterogeneity of nemoral flora of each landscape region (not only for trees as was shown above) can be a main part of future platyphyllous forests unsustainability when climatic conditions oscillations will be revealing.

5.4 Forest Management

Two basic problems are connected within forest management and afforestation in relations with platyphyllous type forest succession in the south and middle taiga subzones of the Northwest European Russia.

Warmer climatic conditions will give most productive broad-leaved trees sylviculture in the region. Some experiments (Timofeev 1966, Kurnaev 1980) demonstrated that lower, second storey of small-leaved lime in Norway spruce forests increase timber production on 40 per cents in comparing with ordinary monodominancy Norway spruce forest, both in sylviculture and in natural communities. Tendencies of climatic changes should give a possibility of extensive small-leaved lime sylviculture development in existing Norway spruce forest areas.

Another question is given by modern technique of plantation and self-sown forestry. Main modern sylviculture strategy in the Northwest European Russia and some neighbored countries is a Norway spruce plantation production and self-sown Norway spruce forests regeneration through semi-natural successions. It is especially important that ordinary reforestation practice uses for recovery genotypes of Norway spruce (and Scots pine too) from the modern most productive populations.

There is no any guarantee that the modern most productive populations will be most productive in the future, in other climatic conditions. Moreover, it is possible that after 40–50 years from reforestation Norway spruce as a boreal species will be suppressed in the North Europe. The present south limit of Norway spruce spreading is placed near 800 km to south from Finland, and only 450 km to south from modern taiga zone board. Where will be southern limit of Norway spruce area when the global climate changes? There is a question which was not analyzed with any simulation model. In these reasons, some improvements of reforestation policy should be given in the interrelations with climate changes processes.

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Total of 27 references