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EXAMPLES OF THE INTERNAL STAND STRUCTURES (Ά-DIVERSITY IN) OLD GROWTH FOREST IN THE YULA RIVER BASIN – ARKHANGELSK REGION*

Рассмотрены результаты анализа структуры старовозрастных древостоев в бассейне р. Юла на основе закладки трансект с подробным картированием размещения деревьев. Отмечено наличие большого биоразнообразия. Предложено использовать подобный инструмент для экологически-базированного модельного леса.

The article present the results of the structure analysis of old-growth stands in the Yula river basin using "transect" with detailed mapping of the trees' location. Rich biodiversity has been observed. Using a similar tool for ecologically-based model forests is suggested.

Key words: Sustainable forestry, timber utilization, intact landscapes, managed forest, natural forest, impact, ecotypes, biodiversity, ecological forestry, transects, ά-diversity, succession stages, gap dynamics.

Introduction

The boreal forests of Norway, Sweden and Finland have for centuries been utilized by local people for many purposes, timber for houses and firewood near settlements, grazing by cattle, sheep and goats, production of tar for impregnation of houses, boats and other wood products, iron production melted out of deposits from iron-bacterial activity in bogs, charcoal for mining industry, and selective logging of timber where logs and planks have been exported to Norwegian and European towns [4]. Some large towns, like Amsterdam, could be said to float or stand on old timber from Norway. This utilization has passed on over centuries. Vast areas of forests were utilized with strong or weaker impact on the forest

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structure until also small sized timber were taken into use in the late 1800^{th} for paper production. Selective logging, followed by natural regrowth, was though the dominant forestry practise until the mid 1900^{th} when clear cutting, regrowth secured by planting of tree-nursery produced trees and intensive cultivation of young stands, became the dominant way of tree harvesting and forest production.

This long time utilization of timber have modified and simplified structure and tree composition of Fennoscandic boreal forests in many ways. Today natural old growth forests with little impact of human activity are seldom found, and mainly in high elevation forests, (near tree line to the mountains), far from human settlements. They are often of small size and scattered in a way that hardly create a forest landscape, and if so - only as narrow belts of trees/forest at the higher elevations. They only represent types of north-boreal forests, and not the diversity of boreal forests that is distributed from south to north and different local ecotypes that could have been found in Fennoscandia.

With a new attitude to, and new definition of the concept *Sustainable forestry*, following the United Nations convention of sustainable development [4], and the Rio-convention of Protection of biodiversity [6], a need to obtain better knowledge of the ecology in natural developed boreal forests has aroused. Such knowledge is of importance if the concern of biodiversity should be implemented in forestry practise. Ideologically a new practise for sustainable forestry, called *ecological forestry*, should be able to copy forests composition at landscape and stand level. This is a difficult task to solve in managed forest, but anyhow regarded as an important tool to maintain biodiversity in managed forests and earlier suggested by Rolstad [3] and Seymoure and Hunter [5]. Today, knowledge of stand structures and natural forest mosaics at landscape level for forests similar to our Fennoscandian boreal forests can only be obtained from similar forest types in North-West Russia, the areas from where the boreal, Fennoscandian flora, fauna and fungi mainly have been recruited.

The aim of this study was to test out a method and document tree structure and forest composition of some common, natural, old growth stands from the boreal taiga zone of Archangelsk region.

Study area

This paper presents results from an excursion into the river basin of Yula and Ura in Pinega and Vinogradovsky rajons in Arkhangelsk Oblast in the spring of 2005 [2].

In this area the terrain is flat or gently sloping. The soil is fine grained, dominated by the silt fraction. The climate is continental, with a precipitation of 400…500 mm per year. Spruce is the dominant tree species. It forms pure stands, but also stands mixed with pine. Pure pine stands occur on sites were the terrain lies higher than the surroundings and the ground water lies deeper in the ground. Broad-leaved species are scarce, but birch is present especially in early succession stages. Most stands are in medium or late succession phases, and often the succession dynamics were complex and intriguing to interpret.

Forest fires are causing the severe disturbances in the forests here. During our five days in the field, we observed one location where a forest fire had swept over a vast area, killing all spruce and birch trees, whereas most of the pine trees had survived. Minor disturbances caused by wind and parasitic fungi were observed on several spots. Most common was wind-thrown, single trees, but spots of 1-2 hectares where all trees had been wind-thrown, were also observed. Due to severe drought the last years, dead or dying spruce trees occurred rather frequently. On sites with dead or stressed trees, bark beetles now were attacking and killing additional trees.

Methods

We measured transects of forest according to the method used by Huse [1] for natural pine forests of the Pasvik Valley in Finnmark, Norway, but now in spruce-dominated forests. Each transect measured was 10 by 50 m. On each transect all standing trees higher than 1m, tree height and diameter at breast height were measured, and positions were mapped. This method will visualize and measure ά-diversity pattern in a forest stand, but not the β-structure defined as the mosaic pattern of forest stands at landscape level [3]. Logs lying on the ground were mapped and classified in early or late decomposition stages. Transect no 1 and 2 were situated on flat terrain, in no 3 and 4 the terrain were gently sloping, and in transect no 5 it was slopes of 8 %.

Symbols used in the mapping of trees in the transects are given i fig. 1. Dead trees lying on the ground are also shown, where trees drawn with solid lines are newly fallen trees and decomposing trees drawn with broken lines.

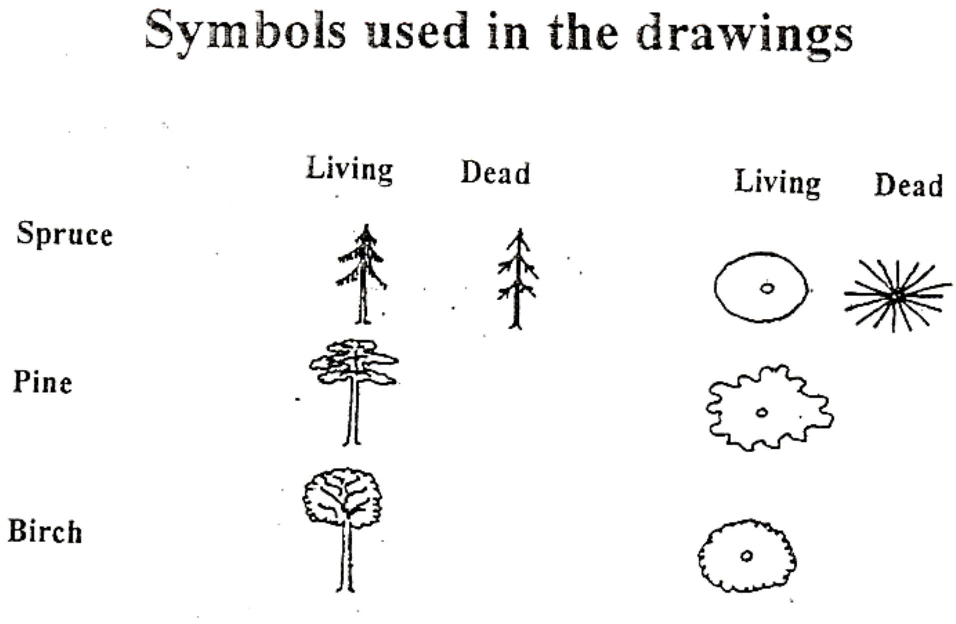

Fig. 1. Symbols used in the drawings

Results

All together, five transects were mapped and investigated, all of them situated in spruce dominated forests of differed ages and succession stages. The number of trees, age of stand and estimated volume is given in table.

Number of trees and standing volume in the five transects. Norwegian volume tables were used to calculate standing volumes

Transect no	Age of dominant trees	Number of trees /ha.	Basal area, m^2/ha	Standing volume, m^3/ha	Remarks
1	250	1340	19	210	Spruce and birch
		100	9	105	Pine
2	250	1520	26	305	Spruce
3	300	2120	17	170	Living spruce trees
		280	7,5	85	Dead spruce trees
4	200	1720	20	145	Spruce
		40	1	10	Pine
5	100	1000	9,5	205	Spruce
	250	120	3	75	Pine
	100	600	6,5	115	Birch

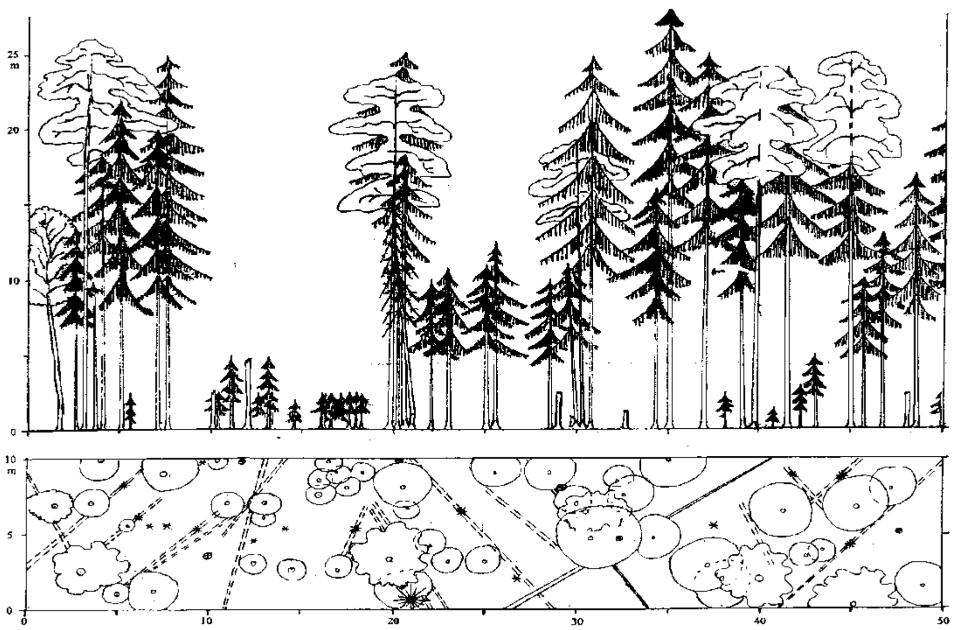

Fig. 2. Vertical- and horizontal projections of a spruce- dominated stand in a medium- or late succession phase. Gap dynamics will now transform the stand towards a multi-layered, multi-aged phase

Transect no 1 was an old tree stand on plain terrain near the Yula River. The soil was fine-grained sand with a thick raw humus layer. Spruce (*Picea abies*) was the dominant species, but a few old pines (*Pinus silvestris*) were mixed in. The oldest trees were about 250 years old and up to 26 m high (fig. 2).

This stand showed a succession after a forest fire more than 250 years ago when only the pine trees survived. Single trees and fallen, decomposing logs of birch (*Betula spp*.) showed an earlier presence of this species. The stand was now in a phase of decomposition, where gap dynamics now will transform the stand into a multi-aged, multi-layered phase. I can also be hit by a fire and thus start a new secondary succession.

Transect no 2 was a continuation of transect no. 1, but the terrain here was about one meter lower and sometimes flooded by the Yula river, probably each spring. The soil appeared to be more fertile, and the dominant trees were 2 m higher and had larger diameters than the trees in transect no 1 (fig. 3).

This pure spruce stand was more even, and gap dynamics had just started. Most of the fallen logs were in early decomposition stages, showing that they had fallen during the last few years. There were only a few logs in late decomposing stages. This corresponded to the stand structure that showed only small gaps, and the regeneration was of young age. The even structure and crown canopy indicate that this stand probably might have been caused by the same fire as transect no. 1.

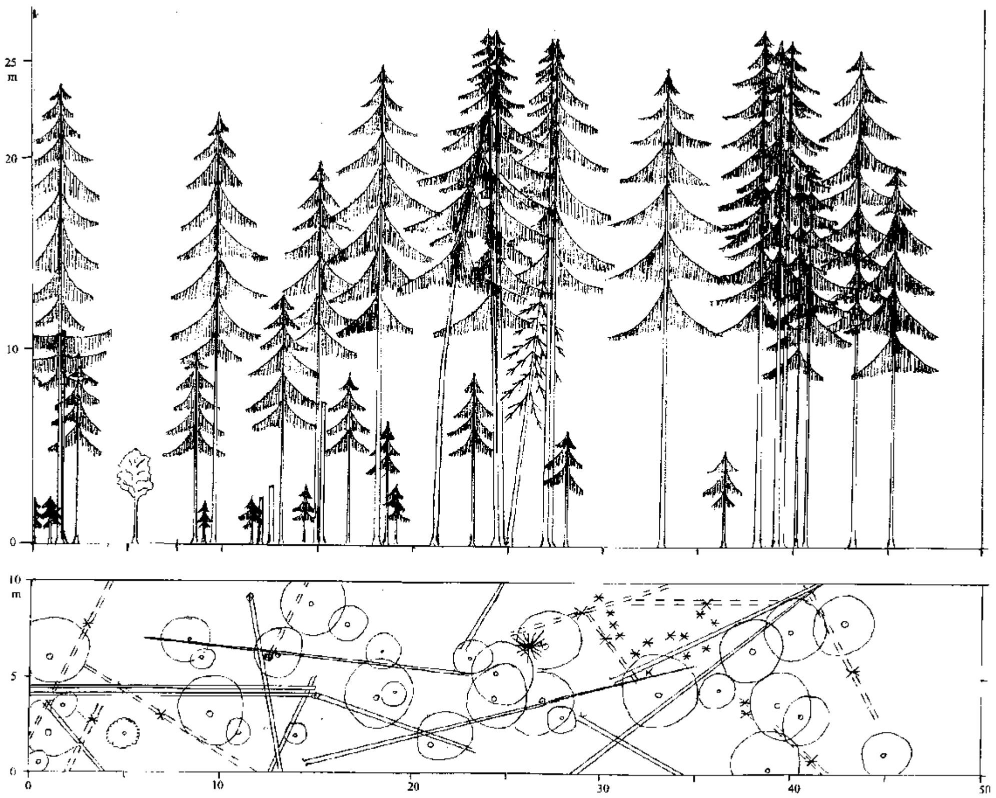

Fig. 3. Vertical- and horizontal projections of a spruce stand in a medium- or late succession phase. Most of the fallen logs were from the last few years. In these gaps regeneration will appear and the stand will develop into a multi-storeyed and multi-aged stand

The fact that this transect lies lower than no. 1, makes it also possible that it was not burned at that time. In this case this stand has developed over a longer period of time. In the right part of this transect, the trees were all old and large, but in the left half there were trees of different ages and heights. This distribution of heights and ages indicates that gap formation and regeneration has taken place in a long period of time.

Transect no 3 was a spruce stand near the river Ura, on fine-grained soil and gently sloping terrain. The dominant trees were 250 – 300 years old, and up to 27 m high. The trees were now suffering under drought stress and severe attack from bark beetles (fig. 4).

The structure of this stand indicates a late succession stage. Here were trees of all ages and heights and also gaps with regeneration. The drought and attacks by bark beetles had killed the largest trees, and if it continues, it will bring the stand back into an earlier succession stage.

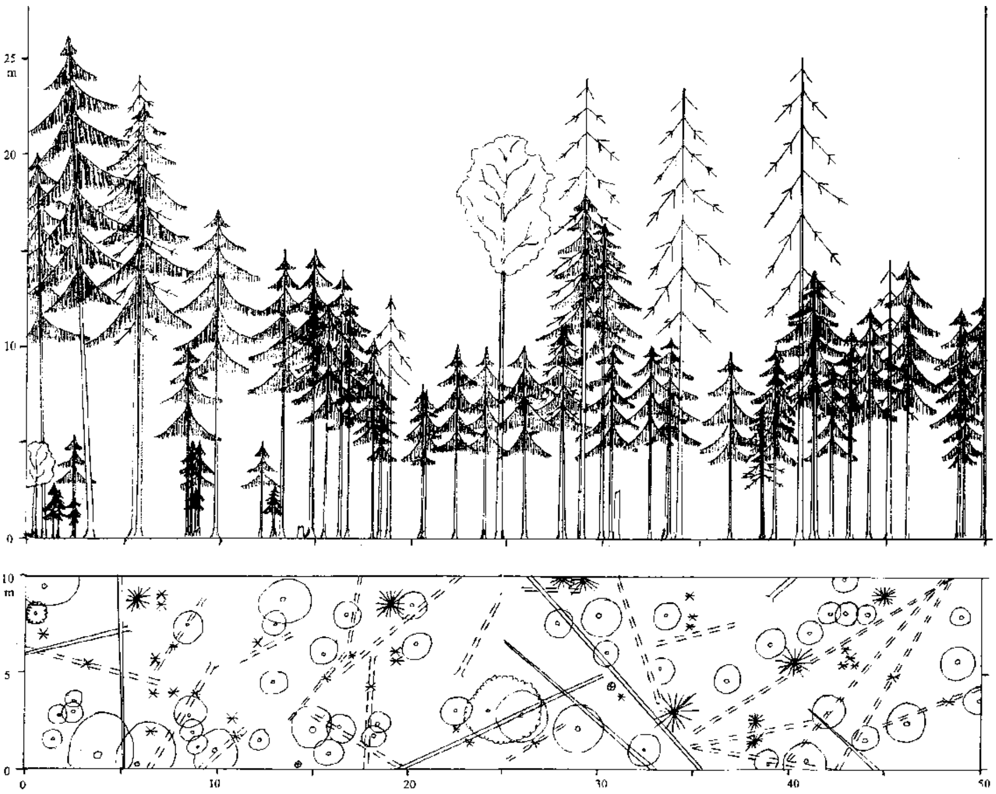

Fig. 4. Spruce-dominated stand near the river Ura on silty soil and gently sloping terrain. The stand was in a late succession phase, now under drought stress and severe attacks from bark beetles. If the killing of the largest and oldest trees continues, the stand will be brought back to an earlier succession stage

Transect no 4 was a spruce stand with some pine trees mixed in, on fine-grained soil and gently sloping terrain near the river Ura. The dominant spruce trees were 150…200 years old, and up to 21 m high (fig. 5).

This transect was only 200 m from transect no 3, and had the same ecological conditions. The stand has developed after a fire 150…200 years ago. The fire did not reach transect no 3, probably because of a small stream between the two transects. The fallen logs caused by the fire were now completely decomposed and not longer visible on the ground. Here and there regeneration occurred on straight lines, indicating that it has generated on rotting logs after the fire, so-called carcass regeneration. Most of the present logs on the ground were now in early stages of decomposition, indicating that the stand was in an early stage of succession. Only a few gaps had so far occurred, and the regeneration was of young age. Some of the largest trees were killed by drought and attacked by bark beetles, thus making new gaps and a more open stand.

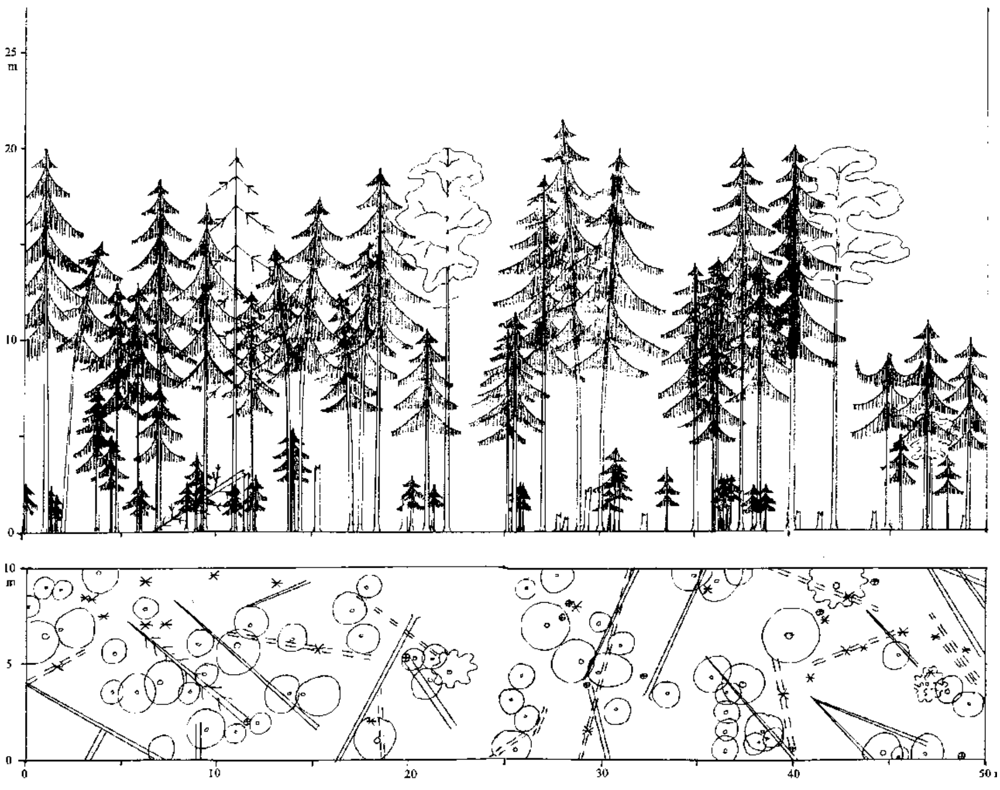

Fig. 5. Spruce-dominated stand near the transect no3 on silty soil and gently sloping terrain. The stand was in an early succession phase, now under drought stress and severe attacks from bark beetles. If the killing of large trees continues, the stand will be more open and more regeneration will develop

Transect no 5 was a mixed stand of spruce, pine and birch on fine-grained soil.

The terrain was sloping 9 % and with an exposition to the west. The pines had survived a fire 100…150 years ago and were about 250 years old. The birch and spruce had generated after the fire. They were up to 25m high and the pines up to 28m high (fig. 6).

The stand was in a phase of elimination, where the birches were losing ground and the spruce gradually would take its place. Lying logs were mainly of small and medium diameters and in early stages of decomposition, which is in accordance with the early succession stage of the stand.

Further development of this stand will be a continuous struggle between individual trees and species. In the end the birches will be supplanted by the spruce, and the stand will be a spruce-dominated stand with a few pine trees. An interesting observation was the lack of regeneration of pine. There must have been seeds from the pine trees after the fire, but they have for some reason not been able to compete as the stand also has regenerated from birch- and spruce seeds brought there from neighbouring stands.

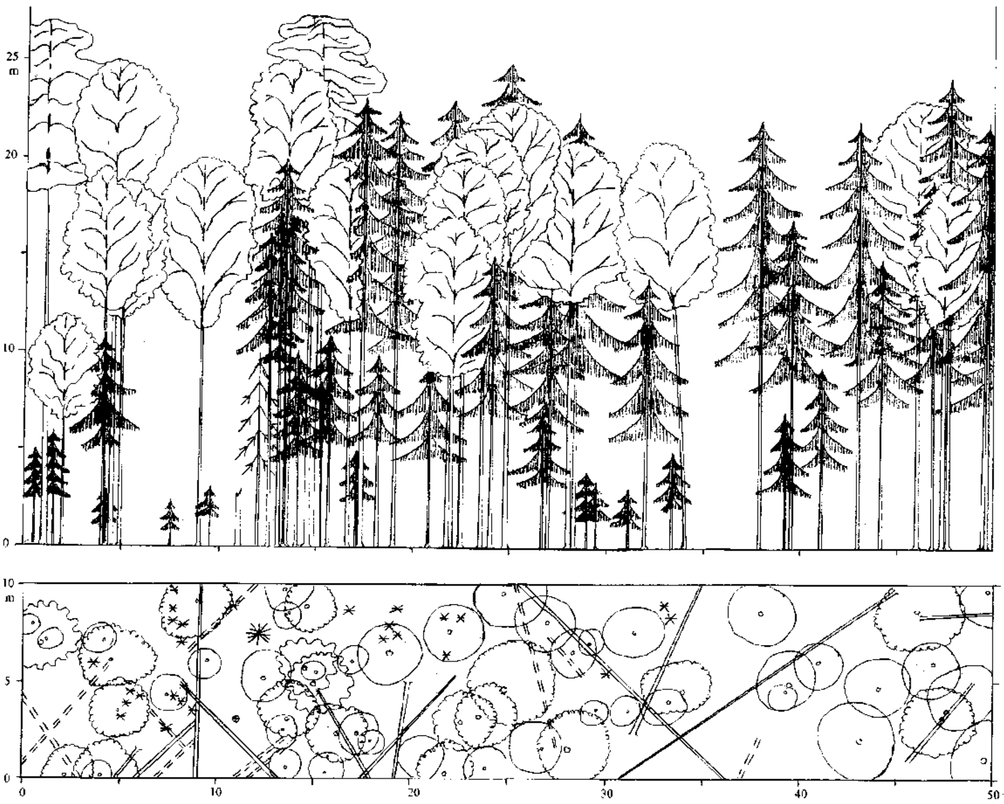

Fig. 6. A mixed stand of spruce, pine and birch in early succession stage. The pines have survived a fire 100-150 years ago, and are about 250 years old, and the spruce and birch have generated after the fire. Now there is a tough competition for survival between individual trees and species. In this struggle the birch will gradually loose, the spruce and pine will be the winners and the stand will be dominated by spruce with a few pines mixed in

Conclusions

We found that such kind of transect descriptions could be a valuable tool to demonstrate by drawings and calculations the different ά-structure of forest stands also in spruce-dominated forests. Our transect descriptions of different forest stands give only brief examples of forest structures from a natural forest landscape with a very complex diversity in succession history. These forests might “from distance” look quite simple with a simple so called β-diversity, but walking in these forests reveals a great ά-diversity, - a complexity of tree stands and structure that hardly nowadays can be found at landscape level in Fennoscandia. If such transects could be measured and described for several forest stands of different successional, and known history, they could be a realistic and useful tool for an ecological based model forest.

We though realize that the forests complexity is large even within forests of same age, but this complexity can and should be demonstrated by further research of the kind described in this article.

In the Yula and Ura forests visited by us in 2005 signs of different forest fires could easily be recognized in pine dominated forests – as the vegetation development of the forest floor was different as well as the regrowth of young pine trees indicated the time since the last fire had passed the spot. In old, spruce dominated forests gap dynamics were easily observed as a combination of wind- and snow broken trees surrounded by newly beetle-killed or beetle attacked and dying trees. The gaps could be quite new or had been extended over decades as we observed regrowth in these spots of different age classes. Fungi (and maybe the species *Fomitopsis pinicola*) were supposed and hypothesized by us to be the primary source for the gap-development.

Anyhow – these intact landscapes of old growth boreal taiga forests represents today a unique possibility to observe and analyze forest succession in western taigas in a way impossible in the long-time human influenced and now recently cultivated forests of Fennoscandia. As such they represent a value in itself as information banks of world value for securing natural ecosystems and its biodiversity.

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