Slutrapport till Skogssällskapet

Projekt: **Kan degenererad skogsmark restaureras för att på nytt ge uthållig skogsproduktion?**

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Projektets löptid: 2013-2015.

Sammanfattning:

Två lokaler med heddegeneration i Norrbotten har studerats: Själlarimheden, Jokkmokk (66,5 ^{o}N 20.2 ^{o}E, 280 m ö.h.) och Kiuhtisvaara, Pajala (67,7 ^{o}N, 23,4 ^{o}E, 300 m ö.h). För att påskynda den långsamma naturliga markförbättringen hade i slutet av 1970-talet planterats kvävefixerande gråal (*Alnus incana* L. Moench) och lupin (sandlupin = alaskalupin; *Lupinus nootkatensis* Donn ex Sims) som skulle ge förna rik på kväve och andra näringsämnen. Detta gjordes på initiativ av generaldirektör F. Ebeling och under ledning av professor Jan-Erik Lundmark, SLU. På Själlarimheden har planterade försöksytor varit inhägnade.

I detta projekt har vegetationen i fält- och bottenskikt, tjockleken på podsolprofilens olika skikt och mineraljordens halt av kväveformer och kol undersökts, liksom kvävehalt i barr/blad från tall, al, björk och lupin. Halter av δ^{15}N har mätts som en indikation på kvävefixeringens omfattning. Hos tall (*Pinus silvestris* L.) som planterades för ca 35 år sedan på de två lokalerna har höjd och brösthöjdsdiameter (DBH) mätts.

En klart synlig förändring är utvecklingen av markens fält- och bottenskikt. Själlarimhedens fältskikt, 1979 helt dominerat av ljung, har nu fler växtareter i fältskiktet och i bottenskiktet finns ett starkt inslag av mossor, en stor skillnad mot 1979 då >90% av marken täcktes av *Cladonia*-arter medan mossor var sällsynta. Även om 35 år kan tyckas vara lång tid så krävs det avsevärt längre tid för att tydliga förändringar i markens podsolprofil ska kunna ses. De kemiska analyserna visar dock att kvävefixerande al och lupin har bidragit till de högre halterna av olika kväveformer och av kol i marken, ett resultat i god överensstämmelse med de förväntningar som fanns då al och lupin introducerades i slutet av 1970-talet.

Projektet har genomförts i samarbete med professor David Myrold, Oregon State University, Corvallis, OR, USA och har finansierats av Skogssällskapet och SLU.

In this project studies were done at the two research sites Själlarimheden, Jokkmokk (66,5^{o} N, 20,2^{o} E, 280 m a.s.l.) and Kiuhtisvaara, Pajala (67,7^{o} N, 23,4^{o} E, 300 m a. s. l.). At Själlarimheden the main nitrogen-fixing species is grey alder (*Alnus incana* L. Moench) and at Kiuhtisvaara there is mainly nootka lupin, in Swedish= sandlupin, also called alaskalupin, (*Lupinus nootkatensis* Donn ex Sims). The nitrogen-fixing species were expected to contribute with both carbon and

nitrogen to the soil and thereby accelerate the natural, but very slow process where the soil should again become able to support a reasonable forest production. The development of plantations and growth of grey alder and lupin during the first years at the two sites were described earlier (Lundmark & Huss-Danell 1981, Huss-Danell 1986, Huss-Danell & Lundmark 1988). In this project fieldwork was done in August at Själlarimheden 2013 and at Kiuhtisvaara 2014. Analyses and measurements were performed similarly at the two sites. The study was performed jointly with Professor David Myrold, Oregon State University, Corvallis, Oregon, USA and had technical help in field and laboratory.

Background, performance and results, Själlarimheden

In one group of experimental plots (7-10) grey alder was planted in 1977 with roadside plants from the neighbourhood (plot 9) and 1979 with nursery plants (plot 7) originating from the area. In addition, lupin was planted (plot 10). For comparison, plot 8 was left without plantations to serve as a control plot, but unfortunately parts of the plot were invaded by alder during the years. The development of plantations and growth of grey alder and lupin during the first years at the two sites was described earlier (Lundmark & Huss-Danell 1981, Huss-Danell 1986, Huss-Danell & Lundmark 1988). In 1983, plots 7-10 were planted with pine (*Pinus sylvestris* L.) after removal of the few small natural pines present. Thereby all planted pines had a similar age and size from their start. In a second group of plots (13-18), nursery plants of alder and pine were planted in 1979 and supplementary in 1983. When alders were planted, some plots were limed and/or fertilized to enhance the growth and leaf litter N production by grey alder. The results of these treatments have been described in detail (Huss-Danell 1986). The planting of pine had been performed as in plot 7-10. Both groups of experimental plots have been fenced.

The soil

When cultivation of alder and lupin took place at Själlarimheden in the late 1970s the expectation was that litter from leaves and needles and from roots, nodules and soil organisms would increase the soil content of nutrient rich substances. Litter degradation and N mineralization would release ammonium and, to some extent, nitrate.

In 2013, the soil profile was studied at ten points along the diagonals in each plot. Organic material was moved aside and mineral soil samples of about 0.1 m in diameter by 0.15 m depth were taken. The sample volume was estimated by placing a plastic bag into the sample pit and filling the bag to the brim of the pit with a known volume of water. The thickness of the podsol layers A, E and B was measured at four locations of the pit. For each plot the 10 soil samples were pooled into a single composite sample and kept cooled until processed in Umeå. pH was measured in the mineral soil fraction <4 mm grain size and soil was extracted in 1M KCl for analysis of ammonium-N and nitrate-N (Department of Forest Ecology and Management, SLU, Umeå). Weighed portions of the soil fraction were dried at 105 ^{o}C and weighed. The dried soil samples were finely ground before analysis of C_{tot}, N_{tot} and isotopes of C and N (OSU Stable Isotope Lab, Oregon State University).

In plots 7-10 as well as plots 13-18 soil pH was on average 5.1 with only small variation. The concentration of ammonium-N in plots 7-10 was lowest in the control plot and three times as high in the lupin plot. As expected, the concentration of nitrate-N was low, typically about one tenth of the ammonium-N concentration in the respective plots.

The concentration of C_{tot} was lowest in the control plot (2.53 %C), but twice as high in the lupin plot. C_{tot} concentrations were higher in the alder plots than in the control plot, but lower than in the lupin plot. Also, the concentration of N_{tot} was lowest (0.09 %N) in the control plot, higher in the two alder plots and highest in the lupin plot where N_{tot} was 5 times as high as in the control plot. The alder plots 13-18 were investigated in the same way as plots 7-10. The C:N ratio in alder plots (7, 9 and 13-18) was very similar. Nitrogen fixation in both alder and lupin appeared to have contributed to the differences in concentrations of C_{tot} and N_{tot} in the soil, a result that agrees with the expectations about planting nitrogen-fixing grey alder and alaskalupin at the site.

Understory vegetation

In 1979 the field layer covered ca. 50% of the ground and was completely dominated by *Calluna vulgaris* (L.) Hull. Patches of *Lycopodium complanatum* L., *Empetrum hermaphroditum* Hagerup., *Vaccinium myrtillus* (L.) and *V. vitis-idaea* L. together made up only 10% cover Huss-Danell 1986). A bottom layer covered about 65% of the ground in 1979 with a composition of >90% by *Cladonia* spp. Only patches of *Stereocaulon* spp., *Peltigera aphthosa* (L.) Willd. and *Nephroma arcticum* (L.) Torss. were seen in the lichen mat. The mosses *Pleurozium schreberi* (Brid.) Mitt. and *Polytrichum juniperinum* Hedw. were very rare (Huss-Danell 1986).

In contrast, both the field layer and the bottom layer were markedly different in 2013. In each plot the coverage of vegetation in the field and bottom layers was estimated in 10 subplots (50x50 cm) along the diagonals of the main plot in order to get a mean value for the plot. The field layer (plots 7-9) was dominated by *Vaccinium vitis-idaea*, *Calluna vulgaris* and *Empetrum hermaphroditum*. In the bottom layer, *Pleurozium schreberi* and *Cladonia* spp. *w*ith some species of the genera *Polytrichum* and *Dicranum* were dominating.

The trees

In the plots 7-9 and 13-18 tree height and DBH were measured on ten pines, >2 m high, nearest the centre of the plot. The mean height was 4.1 m and mean DBH 5.1 cm. No pines had survived in the lupin plot. Leaf and needle samples from pine, alder and birch were taken from current year's shoots at ca. 2 m height on four sides of the trees, and also from lupin. After drying (60 ^{o}C) the samples were finely ground for analysis of N and ^{15}N. The N concentration in each species was fairly similar irrespective of plot, on average 1.11 %N in pine needles, 1.97 in birch leaves, 3.05 in alder leaves and 4.26 % N in lupin leaves. We found δ15N in lupin >alder >birch >pine, which can be understood as lupin and alder had high nitrogen fixation, a high degree of self-support of N while needles and leaves of non-N-fixing birch and pine were more dependent on soil-N.

Background, performance and results, Kiuhtisvaara

At Kiuhtisvaara there are nearly 50 research plots belonging to several projects and scientists. A dozen plots were studied in this project: five plots on non-treated soil and four on ploughed soil. In addition, we laid out four new plots on ploughed soil to serve as control plots.

Grey alder had been planted 1979 in both untreated and ploughed plots. During the first years the survival was good but thereafter very poor. Now, only some few scattered small alders were seen. Their poor survival can probably be explained by climate at the site, the vicinity to the border of alder's natural distribution area (Hultén 1971), and there were also signs of reindeer browsing and sweeping antlers. In some plots on ploughed soil lupin had been planted or sown in 1979. A *Rhizobium* species that can infect and give rise to nitrogen-fixing root nodules on alaskalupin had been added at sowing. Root nodules developed very well on the lupins. Already a few years after plantation and sowing, lupins had invaded several plots with or without planted/sown lupins. Mainly plots on ploughed soil were invaded. In 2014 lupins were spread widely on ploughed soil and were also quite common in untreated soil. Plants now range from small seedlings up to 110 cm height and have up to about 50 shoots per plant. Pine was planted in 1981 in plots both on untreated and ploughed soil. There was no fence at the site.

The soil

The soil was sampled and measurements and analyses were performed in the same way as done at Själlarimheden. Also data were fairly similar to corresponding data from Själlarimheden, for example soil pH was on average 5.0 and concentration of C_{tot} was 4,18 %C as a mean for all studied plots at Kiuhtisvaara.

Understory vegetation

In the field layer *Calluna vulgaris* > *Empetrum hermaphroditum* > *Vaccinium vitis-idaea* > *Arctostaphylos uva-ursi* > *V. myrtillus* were dominating the plant cover. Further, four plots on ploughed soil had as high coverage as 85–100 % by small lupin plants, a clear sign of continued seed spread of the lupin. *Pleurozium schreberi* >*Dicranum* sp. > *Cladonia* spp. had the highest coverage in the bottom layer. Apart from the lupin spreading, the overall impression of the understory was thus quite similar at the two sites Själlarimheden and Kiuhtisvaara.

The trees In each of the 12 plots with pine planted in 1981, tree height and DBH were measured on 10 pines >2 m high nearest the centre of the plot. The height was in the range 2.2 to 11.7 m, mean 7.10 m, and DBH ranged from 1.9 to 32.5 cm, mean 15.7 cm. Compared to the pines at Själlarimheden planted 1979 and 1983 the studied pines at Kiuhtisvaara were about twice as high and their DBH about three times as large.

In conclusion, all the activities at Själlarimheden and Kiuhtisvaara have been performed as planned and as time and other conditions in field have allowed. It appears that nitrogen-fixing grey

alder and alaskalupin are promising tools to improve the quality of the soil so that in future the soil can again reach a quality sufficiently high for forest cultivation.

Kommunikation: Our ambition is still to publish a paper in an international refereed journal and make the paper available as Open Access. Contacts with researchers and teachers at SLU will continue. For popular science communication a contact has been taken with the editor of FAKTA SKOG who is positive to a contribution from this project.

Citerad litteratur

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