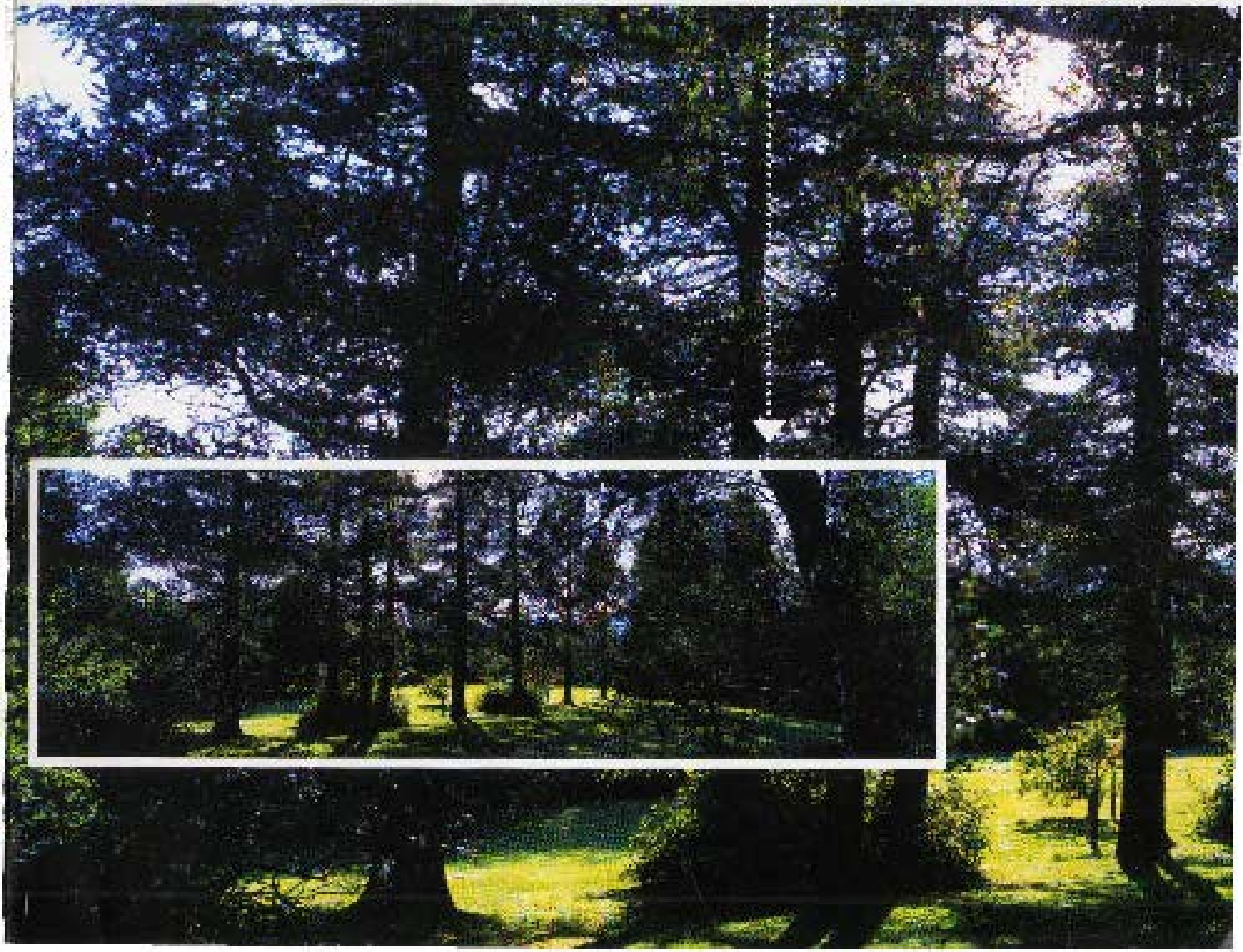
Skógræktarritið 2001

SKÓGRÆKTARFÉLAG ÍSLANDS

1. tbl



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Skógræktarritið er gefið út af Skógræktarfélagi Íslands og er eina fagritið á Íslandi er fjallar sérstaklega um efni sem varða skógrækt og hefur það komið út nær samfellt frá 1930. Þeir sem hafa áhuga á að skrifa greinar í ritið eða koma fróðleik á framfæri eru hvattir til að hafa samband við ritstjóra.

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Skógræktarfélag Íslands er samband skógræktarfélaga er byggja á starfi sjálfboðaliða Skógræktarfélögin mynda ein fjölmennustu frjálsu félagasamtök, sem starfa á Íslandi, með yfir sjö þúsund félagsmenn Skógræktarfélag Íslands er málsvari félaganna og hefur m.a. að markmiði að stuðla að trjá- og skógrækt, gróðurvernd og landgræðslu, auk fræðslu- og leiðbeiningarstarfs. Skógræktarfélagi Íslands er skipuð sjö manna stjórn sem kosin er á aðalfundi, en hann er haldinn einu sinni á ári.

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LITGREININGAR, FILMUR OG PRENTUN: Prentsmiðjan Viðey ehf.
Gefið út í 4500 eintökum - ISSN 0257-8336

Nokkur orð frá ritstjóra

Fyrsta hefti Skógræktarritsins 2001 lítur dagsins ljós í sumarbyrjun, þegar annir ræktunarmanna eru í algleymingi. Vonandi gefst sem flestum færi á að glugga í ritið, sem að þessu sinni er með nýju útliti. Ytra útlit blaðsins hefur verið óbreytt sl. 10 ár. Lögð var áhersla á að kynna og prýða síður ritsins með verkum okkar helstu klassísku málara, þar sem þeir hafa sett niður trönur sínar í íslensku landslagi og fest skóga eða trjágróður á myndflötinn. Bæði er það, að ekki er um auðugan garð að gresja í þessu sambandi, en einnig er tímabært er að breyta til og huga að nýjum viðfangsefnum. Að þessu sinni prýðir forsíðuna ljósmynd Gísla Gestssonar. tekin í Mörkinni á Hallormsstað sl. sumar.

Annað, sem lesendur taka eftir, er hve ritið er efnismikið. Það hefur raunar aldrei verið meira að vöxtum. Ástæða þess er, að á liðnu hausti kom Þröstur Eysteinsson að máli við mig og lýsti yfir áhuga á því að koma á framfæri efni, sem flutt var á tveimur ráðstefnum á Akureyri 27.-30. júní '2000, Skógrækt handan skógarmarka, og samhliða þeirri ráðstefnu var haldinn fundur NSSE (Nordic Subalpine-Subarctic Ecology group), sem er norrænn sérfræðingahópur um vistfræði birkiskógabeltisins. Þá þegar var afráðið að verða við þeirri ósk, ella hefði það efni farið meira og minna hjá garði þorra lesenda og skógræktaráhugamanna. Vonandi er sú leið, sem hér hefur verið farin, vel til þess fallin að vekja áhuga og veita mönnum innsýn í þær víðfeðmu rannsóknir sem stundaðar eru í heiminum á nyrstu endimörkum skóganna. Það ánægjulega er að innlegg okkar íslensku sérfræðinga er fullkomlega sambærilegt við það sem verið er að gera annars staðar í heiminum og sýnir að við eigum frábæra vísindamenn á þessu sviði.

Skógræktarritið hefur leitast við að kynna lesendum sínum eitt og annað fróðlegt er tengist skógrækt og ávallt verið athvarf þeirra sem hafa frá einhverju markverðu að segja. Haft hefur verið að leiðarljósi að bjóða upp á almennan fróðleik og einnig hefur ritið verið áreiðanlegur lendingarstaður fyrir fræðilegar greinar. Áfram verður haldið á þeirri sömu braut. Ræktun þekkingar á sviði skógræktar og umhverfismála er ekki síst mikilvæg þegar skógrækt er vaxandi og æ meiri fjármunum er varið til þessa málaflokks.

Höfundar efnis í þessu riti:

Aðalsteinn Sigurgeirsson, Skóg.lic.Dr., skógerfðafræðingur, forstöðumaður Rannsóknastöðvar Skógræktar ríkisins, Mógilsá

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Lárus Heiðarsson, skógfræðingur, Skógrækt ríkisins, Egilsstöðum

Magnús Jóhannesson, formaður Skógræktarfélags Íslands

Sigurður Blöndal, skógfræðikandídat, fyrrverandi skógræktarstjóri, Hallormsstað

Vilhjálmur Lúðvíksson, framkvæmdastjóri Rannsóknarráðs Íslands

Þröstur Eysteinsson, Ph.D., [illegible]fræðingur, fagmálastjóri Skógræktar ríkisins, Egilsstöðum

Höfðingleg gjöf til Skógræktarfélags Íslands

ÁRMANN GÍSLI JÓNSSON

Nýlega barst Skógræktarfélagi Íslands vegleg gjöf frá Ármanni Gísla Jónssyni trésmíðameistara í Reykjavík. Ármann Gísli andaðist þann 30. janúar sl. og arfleiddi félagið að eigum sínum. Frá gefanda fylgdu engar sérstakar kvaðir um hvernig gjöfinni skyldi varið til eflingar skógrækt í landinu. Ármann var fæddur á Gróustöðum í Geiradalshreppi 31. desember 1904. Foreldrar hans voru hjónin Jón Torfi Magnússon bóndi á Gróustöðum og Guðbjörg Sigríður Bjarnadóttir. Bræður Ármanns voru Magnús vélstjóri, Bjarni sjómaður, Sigurbjörn bóndi á Ingunnarstöðum í Geiradal og Stefán Eyjólfur múrari.

Ármann var sex ára þegar faðir hans féll frá en við það leystist heimili fjölskyldunnar upp. Hjónin Guðjón Jónsson og Sigrún Eyjólfsdóttir á Múla í Gilsfirði tóku þá Ármann í fóstur. Síðan lá leið hans í Króksfjarðarnes en um tvítugt hélt Ármann til Reykjavíkur og lærði trésmíði hjá Árna Erasmussyni húsasmíðameistara. Vann hann eftir það við húsbyggingar bæði hjá öðrum og á eigin vegum til 1946. Árið 1948 réðst hann sem verkstæðisformaður til Tómasar Vigfússonar byggingarneistara og starfaði á innréttingaverkstæði hjá honum til sjötugs.

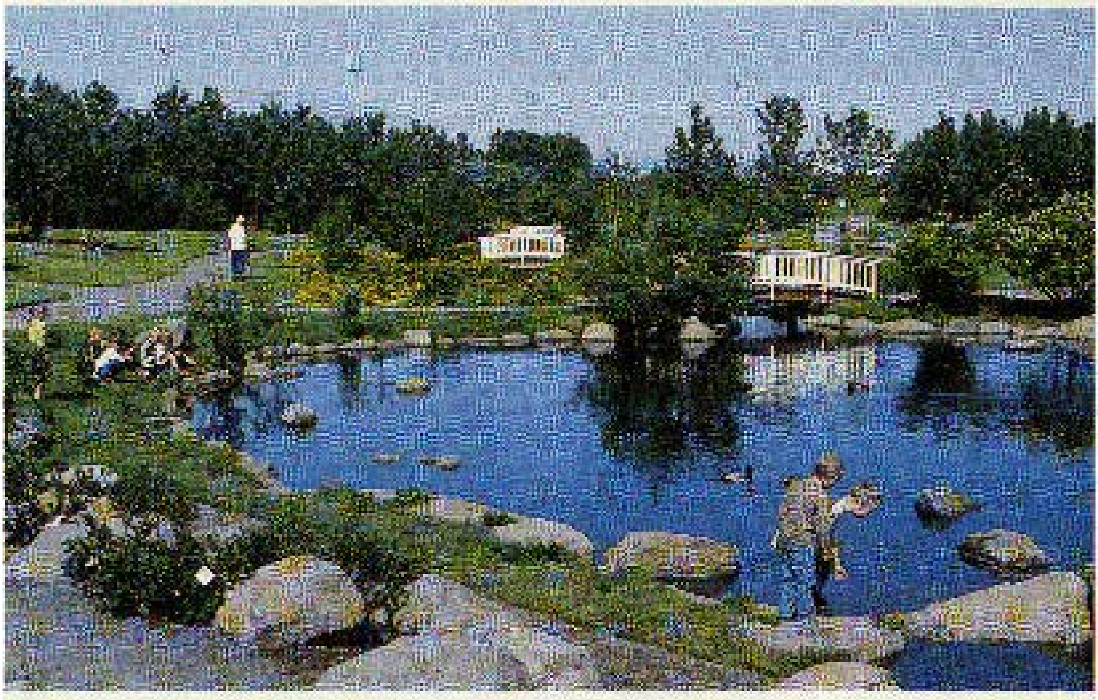
Ármann var hagleikssmiður, bæði listfengur, hugmyndaríkur og vandvirkur. Halldór Stefánsson, bróðursonur Ármanns, lýsir frænda sínum m.a. þannig, að hann hafi verið kröfuharður um efnivið til smíða og að það hafi ekki verið fyrir nema kjarkaða að aka honum til efniskaupa í timburverslunum þar sem hann fann að öllu og þótti enginn viður nógu góður. „Ekki nothæf spýta til í þessu húsi“, tilkynnti hann gjarna afgreiðslumönnum, gekk svo milli stæðnanna, fussaði og taldi upp gallana: „Hrár andskoti, ekki hálfþurrkaður, allt í kvistum og svo er þetta undið og snúið“. Við handverkið gætti engrar óþolinmæði. Viðurinn kom úr höndum hans fáður og gljáandi, fagursnúin handrið, renndir pílárar og fleira sem varð hans iðja er hann lét af störfum hjá Tómasi Vigfússyni.

Um áttrætt keypti hann sér litla íbúð og bílskúr, í þjónustuíbúðum fyrir aldraða í Bólstaðarhlíð 45. Þar kunni hann vel við sig og átti góða elli. Naut hann aðstoðar Kristínar Þórðardóttur sem var honum einstök hjálparhella. Ármann var ókvæntur og barnlaus.

Á fundi stjórnar Skógræktarfélags Íslands þann 2. maí sl., þar sem þessari höfðinglegu gjöf var fagnað, var samþykkt að stofna sjóð í nafni Ármanns og að ávöxtun sjóðsins yrði varið til starfsemi félagsins og eflingar skógræktar í þágu þjóðar.

Félagið mun með þessum hætti halda nafni gefanda á lofti um ókomin ár og Ármanns verður þannig minnst sem eins af helstu velgjörðarmönnum Skógræktarfélags Íslands.

Magnús Jóhannesson,
formaður Skógræktarfélags Íslands.



Velkomin í skrúðgarða og útivistarsvæði Reykjavíkurborgar

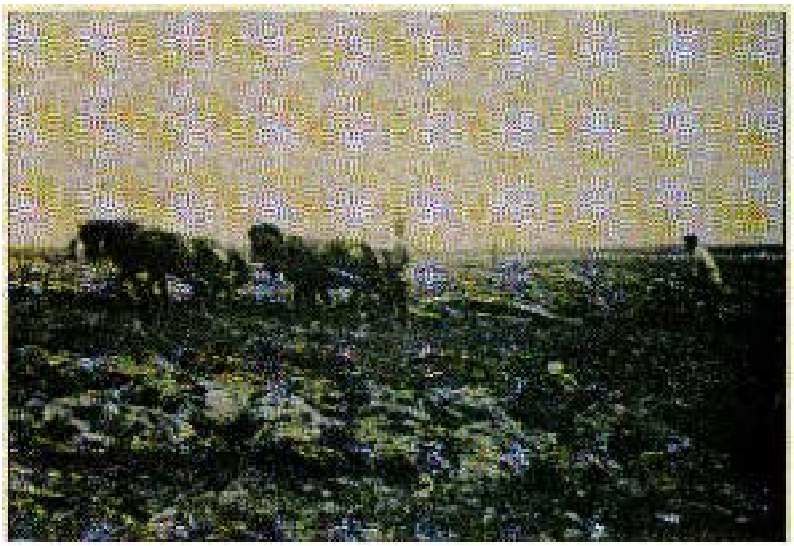
Grasagarður Reykjavíkur
er 40 ára á þessu ári,
fjölbreytt hátíðardagskrá
verður í allt sumar

Reykjavíkurborg
Garðyrkjustjóri

VILHJÁLMUR LÚÐVÍKSSON

Að breyta landi

Í fyrri tveim greinum um skóg-rænt áhugamannsins var fjallað um uppsprettu áhugans á skóg-rækt, bent á nokkra frumkvöðla í nágrenni Reykjavíkur og sagt frá reynslu af 40 ára starfi fjölskyld-unnar við Hafravatn. Í þessari síðustu grein er fjallað um þær breytingar sem sýnilega eru að verða á landinu fyrir áhrif land~græðslu, skógræktar og gróður-bótastarfs og sagt frá draumum um framtíðina.



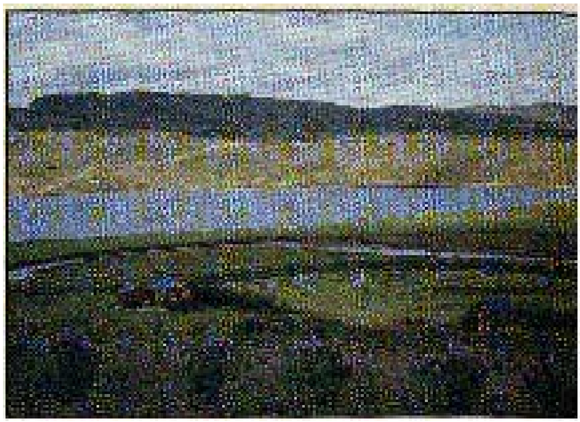
Mynd 1. Við upphaf skógræktar á Jótlandsheiði um miðja 19. öld.

Hugað að samhengi

Myndin (mynd 1) hér til hliðar vísar í hið trúarlega og um leið skáldlega hlutverk mannsins við upphaf ræktunar. Stritandi er hann að brjóta landið undir sig, sjóndeildar-hringurinn endalaus. eilífðar-verkefnið fram undan. Landið gæti verið hvar sem er á jörðinni, - líka á Íslandi. Í raun er þessi mynd þó tekin á hinum skóglausu Jótlandsheiðum í Dan-mörku við upphafið að skógrækt-arstarfi Heiðafélagsins þar um miðbik nítjándu aldar. Þangað átti eitt sinn að flytja alla Íslendinga undan hörmungum Skaftárelda og móðuharðinda. Á þessu svæði eru nú miklir skógar og landið vafið gróðri. Þar hófst verkið með því að djúpplægja heiðina og brjóta upp álúnsleirlagið undir ófrjóum lyngmóunum sem myndast höfðu við ánauð beitarbúskapar í þúsundir ára. Leirlagið hindraði m.a. vatns- og efnabúskap jarðvegsins og rætur trjánna komust ekki niður úr því.

Að gefnu tilefni tillögunnar um flutning Íslendinga á Jótlandsheiðar skrifaði Hannes Finnsson árið 1785 ritið Um mannfækkun af hallærum á Íslandi. Hann var

Mynd 2. Brekkukot við Hafravatn. Hólmsheiði í baksýn.



Mynd 3. Fyrstu lúpínurnar í brekkunni farnar að dreifa sér (1966).

þá nýorðinn biskup að Finni föður sínum látnum og sat sem fastast í rústum Skálholtsstaðar sem búið var að leggja niður af yfirvöldum í Kaupmannahöfn (Íslandssaga til okkar daga, Björn Þorsteinsson og Bergsteinn Jónsson, 1991). Niðurstaða Hannesar biskups af rannsóknum eftir sögulegum heimildum á því hvort búandi væri í landinu var, þrátt fyrir allt, þessi:

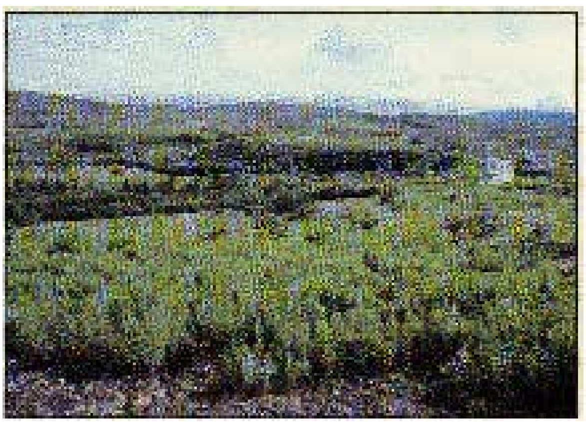
> *Ísland fær tíðum hallæri, en ekkert land í Norðurálfunni er svo fljótt að fjölga á ný manneskjum og bústofni sem það, og er því eigi óbyggjandi.*

Ekkert varð af flutningi Íslendinga á Jótlandsheiðar en þessi mynd þaðan og samhengi hennar við sögu Íslands gefur tilefni til að velta fyrir sér þeim breytingum sem gætu verið fram undan í landinu fyrir tilverknað okkar sjálfra. Hver er afrakstur og áhrif af starfi okkar, hvort sem við köllum okkur áhugafólk eða erum í fullu starfi að „gróðurbótum" í landinu? Það minnir aftur á sögusvið þessa greinaflokks, landið hér ofan við Reykjavíkurborg (mynd 2).

Af lúpínu og líffræðilegri fábreytni

Þegar við fjölskyldan byrjuðum ræktunarstörf við Hafravatn um 1960 fengum við góð ráð hjá Axel Helgasyni og Sonju konu hans, m.a um ágæti Alaskalúpínunnar. Við fengum að stinga upp lúpínuhnausa uppi í Selmörk og flytja bæði í Hákot og Brekkukot. Sverrir tengdafaðir minn setti 20 hnausa í röð í miðja brekkuna, - í beran, leirblandaðan melinn (mynd 3). Þaðan breiddist lúpínan undrafljótt út með vatni og leirrennsli niður melinn og með vindi upp brekkuna og til allra hliða (mynd 4). Á þessum 40 árum sem liðin eru hefur hún þakið nánast allt land innan girðingar sem ekki var gróið fyrir - og auðvitað líka laumað sér inn á svæði þar sem nærveru hennar var ekki óskað sérstaklega. Hún er frek, en þó ekki til verulegs skaða.

Eftir 30 ár fóru að sjást greinileg merki um að hún væri farin



Mynd 4. Lúpínan hefur að mestu þakið melinn innan girðingar (1999).

Mynd 5 .... og farin að hörfa þar sem hún var fyrst sett.

Mynd 6. Sjálfsáin tré og runnar. Þrestirnir sá reyni og rifsberjum.

Mynd 7. Jökulmelurinn orðinn að frjósamri mold.

að hopa (mynd 5). Plönturnar lifa takmarkaðan tíma og þegar mosi og gras hafa lokað sverðinum ná nýju fræin ekki að spíra en aðrar tegundir taka við. Ýmsar tegundir virðast vaxa sérstaklega vel í lúpínumoldinni, t.d. öspin og margar víðitegundir, að maður ekki tali um reyni og berjarunna sem vaxa af fræjum sem fuglar bera og dreifa (mynd 6). Sumar tegundir þola lúpínujarðveginn hins vegar illa og mynda veikar eða vanskapaðar rætur. Það virðist t.d. gilda um furur. Jafnvel birkið getur fengið of mikið af því góða og fallið út af, sérstaklega ef það hefur verið í samkeppni við lúpínuna um birtu á fyrstu vaxtarárunum. Berjarunnar vaxa hratt en blöðin eru oft dökkgræn og kryppluð af of miklu köfnunarefni fyrstu árin.

Aðalatriðið er þó að lúpínan hefur gjörbreytt jarðveginum á jökulmelunum. Þar er komin mjúk og feit gróðurmold þar sem áður var dauður leir og möl (mynd 7). Sá jarðvegur er morandi af lífi, ekki síst ánamöðkum og ýmsum skordýrum, og mikil lífræn framleiðsla er í gangi, bæði mosi, gras og sjálfsáin tré, þ.á.m. gulvíðir, loðvíðir, viðja, birki, reynir, sólber og rifs (mynd 8). Fuglar sækja í lúpínuna skordýr og ber og sennilega fiturík lúpínufræin á haustin. Sama gildir um hagamýsnar. Hrossagaukur og þröstur kunna sérstaklega vel að meta lúpínuna og eiga þar dýrlega veislu langt fram á haust. Þeim hefur stórfjölgað

Ég tel því einhliða talningu og niðurtalningu á tegundafjölda háplantna á gróðursnauðum melum til marks um áhrif lúpínunnar á líffræðilega fjölbreytni stórgallaðan og einhliða mælikvarða á vistfræðileg áhrif hennar. Áhrifin eru augljóslega einnig mjög háð tíma og gróðurframvindu til lengri tíma litið. Þar

Mynd 8. Rifsið hlaðið berjum í sumarlok. Veisla fram undan hjá þröstum.

með er ekki sagt að lúpína eigi alls staðar erindi. Ályktanir sem hafa verið dregnar og einhliða áróður gegn lúpínu og innfluttum tegundum byggður á þeim eru ekki sæmandi þeim fræðimönnum sem gerst hafa forgöngumenn einhliða og afmarkaðrar tegundar náttúruverndar. Ekki er hægt að taka alvarlega þá tegund náttúruverndar sem rökstudd er með „verndun" svokallaðs líffræðilegs fjölbreytileika, á landi sem af þekkingarleysi og neyð hefur verið eyðilagt af forfeðrum okkar. Það var umhverfisslys á heimsmælikvarða sem okkur ber skylda að bæta fyrir. Öllum með opin augun og til þekkja er ljóst að líffræðilegur fábreytileiki en ekki fjölbreytni - er gróðurfarslegt megineinkenni þessa lands! Meðal annars þess vegna hefur það ekki þolað þá nýtingu sem á það var lagt. Hins vegar sýnir reynsla af ræktunartilraun tuttugustu aldarinnar að með réttri meðferð getur það borið margfalt fleiri tegundir og gefið af sér margfalda uppskeru á við það sem gerist í dag, á meðan veðurfar versnar ekki hér á landi. Siðvitund mín mitt segir að okkur beri fyrst og fremst skylda að nota þekkingu okkar og reynslu til bæta fyrir spjöll fyrri alda og

Mynd 9. Lúpínan farin að sækja suður yfir girðingu eftir friðun Hólmsheiðar (ca. 1986).

Mynd 10. Á hraðri leið suður á Hólmsheiði (1999).

Mynd 11. Hér mætir fylkingin að sunnan.

búa í haginn fyrir betra mannlíf hér á landi í framtíðinni.

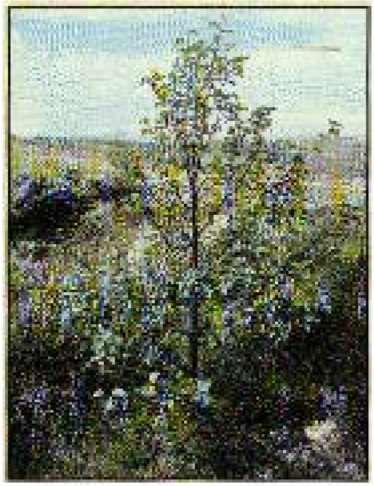
Eftir að sauðbeit var aflögð í Mosfellssveit og Hólmsheiði fyrir 10-12 árum fór lúpínan að breiðast út fyrir girðingu hjá okkur og er nú á hraðleið til suðurs og vestur út á heiðina ca 10-20 metra á ári (mynd 9) Vegna undirbúnings þessara greina fórum við hjónin að kanna hvað er að gerast í kringum okkur. Myndir 10 og 11 sýna hvernig lúpínan hefur sótt út á melásana til suðurs.

Þar sýnist mér hún hafa mætt svipaðri herfylkingu sem ættuð er frá sumarbústöðum við Langavatn. Mikil fjöldi smáplantna er nú að vaxa upp á þessu svæði.

Mikið ber á sjálfsánum trjáplöntum sem hafa náð sér á strik eftir að beitinni var aflétt (mynd 12) Loðvíðir, viðja og birki er orðið mjög áberandi í suðvestur frá Miðdal þar sem ekki er ólíklegt að sé uppspretta fræframleiðslunnar (mynd 13) Hér er einnig að finna dæmi um beinstofna fagurbjörk, raftvið framtíðarinnar sem hér rís upp í heiðinni án nokkurs skjóls, rétt sunnan við fyrirhugað vegarstæði milli Vesturlandsvegar í Mosfellsbæ og Suðurlandsvegar við Geitháls (mynd 14) Vonandi verður henni hlíft við framkvæmdirnar.

Mynd 12. Sjálfsáið birki úti á heiðinni.

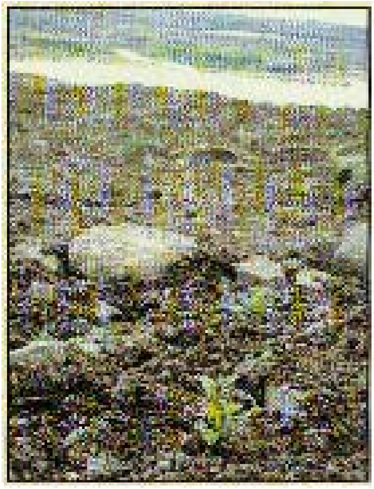
Mynd 13. Sjálfsáinn víðir og birki undan vindátt frá Miðdal (1999).



Mynd 14. Raftviður framtíðarinnar.

Nýtt landnám

Þegar ég fór til að taka myndirnar ofan af Hafrafelli sá ég á leið minni hvað Skógræktarfélag Mosfellssveitar undir formennsku og stjórn Guðrúnar Hafsteinsdóttur hefur verið mikilvirkt á síðustu 10 árum. Hátt uppi í Hafrafelli rakst ég á þessar lerkiplöntur sem þrátt fyrir greinilegt harðræði á berangrinum eru ákveðnar í að vaxa upp þarna (mynd 15). Í baksýn sést til Hafravatns og grillir í Seljadalsá. Á örfoka melum neðar í hlíðinni gladdi mig að

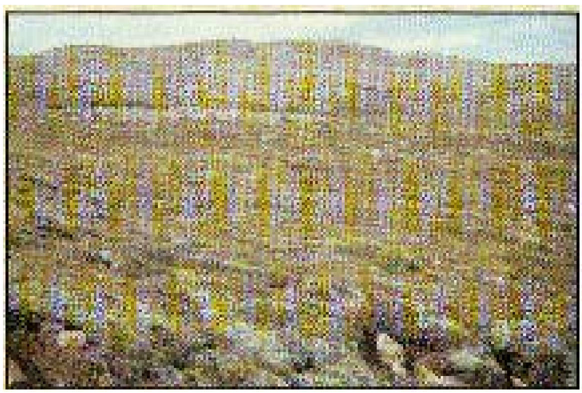


Mynd 16. Elriplöntur með nesti af hrossaskít á gróðurlausum mel.

elri hafði verið plantað og borið ríkulega á af hrossaskít (mynd 16). Það verður gaman að fylgjast með þessu í lautum, þar sem meiri jarðvegur var og skjól fyrir versta norðaustan næðingnum, hafði verið plantað furu, greni og lerki sem virðist ætla að ná sér upp, þótt hægt fari og ein og ein grein tapist í orrustum við skaraveðrin (mynd 17). Ég gladdist mjög yfir þeirri bjartsýni sem einkennir starf Skógræktarfélags Mosfellssveitar og þeim árangri sem er að verða sýnilegur og bendi mönnum á að skoða þetta - Hér er mynd sem gefur svolítið yfirlit yfir starfssvæði félagins í landi Þormóðsdals og árangurinn farinn að koma í ljós (mynd 18).

Heiðarbýlingar

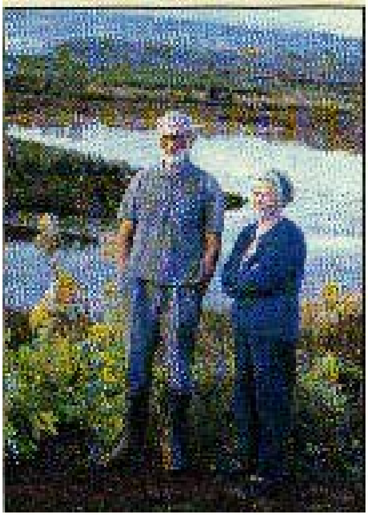
Í þessari heiðaskoðun minni hitti ég hjónin Árna Friðjónsson og Helgu Hjálmarsdóttur sem fyrir um 20 árum keyptu sér 4 ha land við Heytjörn, rétt sunnan við Dalland og ofan við Lynghól (mynd 19). Árni er mikill ná-



Mynd 17. Sitkagreni, lerki og fura að ná fótfestu í lyngmóarytju.

Mynd 18. Hvernig mun þessi hlíð líta út eftir einn mannsaldur?

Mynd 15. Nokkrar lerkiplöntur spjara sig við erfið skilyrði uppi undir brúnum Hafrafells.



Mynd 19. Landnemar við Heytjörn, Árni og Helga.

kvæmnismaður og lætur ekki kylfu ráða kasti um gróðursetningu. Hver hola er vandlega staðsett og merkt og fyllt með vel brotnum hrossaskít árið áður en plöntun hefst (mynd 20). Árni segist ekki þola að sjá eina einustu plöntu deyja vegna handvammar af sinni hálfu. Hann hefur tekið stórvirka tækni í sína þágu og lætur ýta mosa og lyngrudda ofan af og slétta út rofabörð áður en plantað er í endurbættan jarðveginn. Ég kvaddi þau hjón við „Gullhauginn“ sinn í kvöldsólinni og sé fyrir mér hvernig þau eru að breyta heiðinni fyrir ofan Borgina (mynd 21).

Sama myndin blasir við í Dallandi, næsta bæ við Heytjörn. Þar eru Gunnar Dungal í Pennanum og Þórdís Sigurðardóttir myndlistarkona að flétta saman hrossarækt á háu plani við stórtækt uppgræðslu- og gróðurbótastarf. Sérstaklega er athyglisverður árangurinn sem þau hafa náð í skjólbeltarækt (mynd 22). Hrossin fá skjólið fyrir næðingnum á heiðinni en trjábeltin verða vöxtuleg og njóta hrossanna í hringrásinni

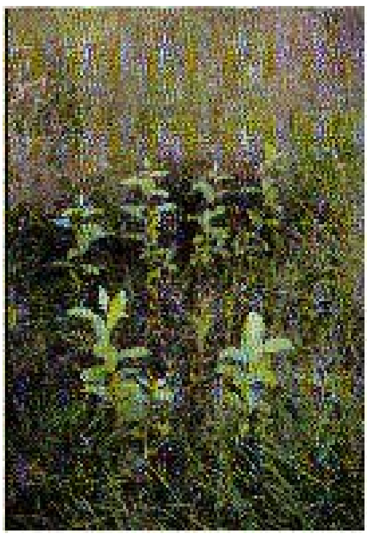
Mynd 20. Vandað til verks!

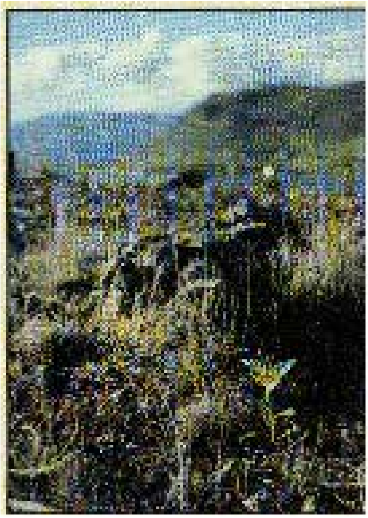
Mynd 21. Búfjárhaugurinn vel brotinn er gullsígildi!

Mynd 22. Þétt er skipað í skjólbeltin að Dallandi. Sambýli hrossa og víðis!

góðu! Alaskavíðirinn breiðir sig síðan út með sáningu þar sem góð móttökuskilyrði eru fyrir fræ hans snemma að sumrinu (Mynd 23). Jafnvel hér á hákollinum á blásnum mel reynir alaskavíðirinn fyrir sér (mynd 24). Ég þori ekki að gera mér vonir um glæsta framtíð þessarar fræplöntu sem ég fann í skoðunarferð minni.

Mynd 23. Alaskavíðirinn er farinn að breiðast út, sjálfsáinn.



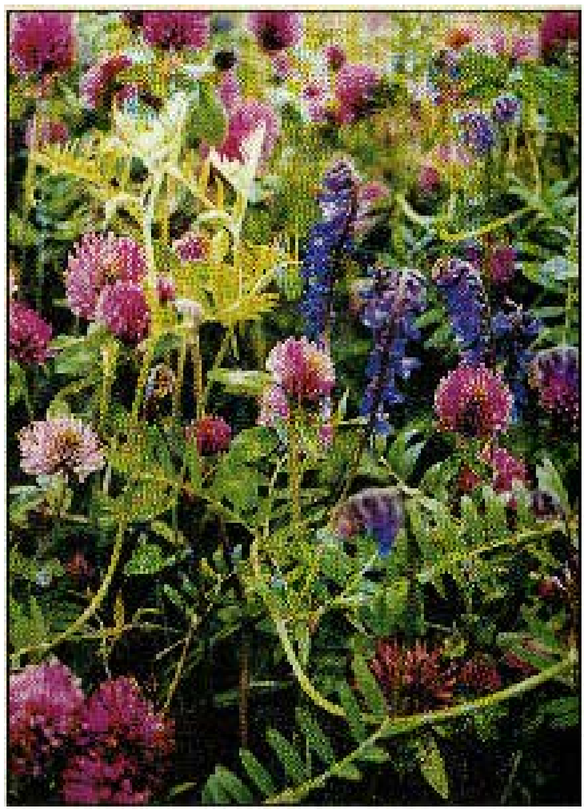


Mynd 24. Það er fallegt útsýnið af melkolli en lífsbarátta víðiplöntu verður hörð.

Hið nýja gróðurlendi - Um siðfræði gróðurbótastarfs

Skógrækt og landgræðsla og ekki síst sáning lúpínu felur í sér miklar breytingar á gróðurfari og um leið breytta landnýtingu. Það vekur til umhugsunar um markmið og tilgang alls gróðurbótastarfs. Það fyrsta sem kemur upp í hugann er að Ísland er í dag gróðurfarslega óralangt frá því jafnvægisástandi sem náttúruskilyrði bjóða upp á ef óskað er hámarks framleiðslu gróðurlendisins. Náttúrulegur íslenskur gróður er heldur alls ekki sá sem sýnir mest viðnám eða þolir best þau áföll og sveiflur í veðurfari sem við höfum þekkt á þessari öld, þar með talið hretið 1963. Tegundafátækt og lítil afkastageta íslensku flórunnar er ekkert síður ástæða þess hvernig komið er fyrir gróðurþekju landsins en ofbeit, jarðvegsgerð og óáran. Hér vaxa t.a.m. fáar innlendar tegundir belgjurta og annarra sjálfbjarga jurta sem framleiða eigin köfnunarefni. En köfnunarefnisbúskapur er einmitt sá þáttur sem hvað mest takmarkar afkastagetu gróðurlendisins (mynd 25).

Vegna þessa er leit að heppilegum erlendum plöntum og trjátegundum, aðlögun þeirra og kynbætur afar mikilvægt verkefni í gróðurbótastarfi framtíðarinnar. Sama gildir um þróun aðferða til að nýta sambýlisáhrif milli tegunda, þ.m.t. örvera og plantna. Þar mun nýfengin þekking á sviði líftækni í vaxandi mæli koma okkur að gagni. Ég hef átt þess kost að fylgjast með þróuninni á þessu sviði í starfi mínu sem framkvæmdastjóri Rannsóknarráðs Íslands. Síðan hafa frístundirnar í Brekkukoti og félagsskapur við kunnáttufólk gefið mér góða innsýn í það hvernig þetta gerist í reynd og eftir hverju er að slægjast Ég veit að hugmyndir um gróðurbætur eins og hér eru settar fram eru umdeildar. Ég sé hinsvegar engin haldbær, siðfræðileg rök fyrir því hafna því að bæta gróðurfar landsins með þessum hætti frekar en að taka ekki með gestrisni og myndarskap á móti öðrum nýbúum til landsins! Manninum, eins og öðrum lífverum, er áskapað að tryggja hagsmuni sjálfs sín og heill tegundarinnar með því að afkomendurnir lifi af. Honum er það hagfellt að hafa umhverfið frjósamt og skjólgott í víðasta skilningi. Hann þarf að vernda umhverfið og náttúruna fyrst og fremst sjálfs sín vegna, en ekki vegna hagsmuna annarra lífvera. Honum er það andlega og efnahagslega nauðsynlegt að umhverfið sé heilbrigt og í jafnvægi. Fjölbreytni gegnir þar lykilhlutverki. Þannig getur maðurinn lifað í sátt við umhverfið, en hlýtur þó að setja mark sitt á það. Það er verkefni vísindarannsókna að kanna hvernig stuðla megi farsællega að þeirri sátt.



Mynd 25. Belgjurtir eru fáar í flóru Íslands.

Mynd 26. Umfeðmingurinn var einn fyrir í Brekkukoti en breiðist hratt út og er gjöfull á köfnunarefnið sem hann aflar.

Mynd 28. Fjallaflækja frá Alaska og refagandur frá Kamtsjatka kunna vel við sig.

Að breyta gróðurlendinu - Áhersla á fjölbreytni

Eftir að skjól tók að myndast og lönd okkar við Hafravatn nálguðust að verða í meginatriðum fullplöntuð hef ég gefið meiri gaum að fjölbreytni gróðursamfélagsins á svæðinu. Belgjurtirnar eru sérkafli. Eina innfædda belgjurtin í landi Brekkukots sem ég sá á fyrstu árunum var stakt, blómstrandi eintak af umfeðmingi *(Vicia cracca).* Hann hefur síðan breiðst út með ótrúlegum hraða þar sem skilyrði hafa hentað honum (mynd 26). Mér er ekki ljóst hvernig því ekki er fræmyndunin mikil. Hugsanlega hefur verið meira af honum en beit haldið honum niðri. Fuglaertur (*Lathyrus pratensis*) flutti ég í landið úr Haukadal fyrir um 10 árum og breiðast þær undrafljótt út með jarðrenglum. Giljaflækju (*Vicia sepium*) flutti ég frá Kirkjubæjarklaustri, haustið sem Skógræktarþingið var haldið þar og breiðist hún út rólega (mynd 27). Sama gildir um íslenska baunagrasið (*Lathyrus japonicus* ssp. *maritimus*) sem kom um svipað leyti. Gullkollur (*Anthyllis vulneraria*) var líka fluttur í landið á svipuðum tíma en fer sér mjög hægt. Innfluttu tegundirnar virðast líka una sér vel eins og fjallalykkjan (*Hedisarum alpinum*) frá Alaska, refagandurinn (*Thermopsis lupinoides*) frá Kamtsjatka (mynd 28) og að sjálf-

Mynd 27. Giljaflækjan er lítið útbreidd og óvíst hvað hún getur.

Mynd 29. Nokkrar gamalreyndar tegundir garðblóma dafna vel í skógarnýræktinni.

Mynd 30. Úr kotgarðinum í Brekkukoti!

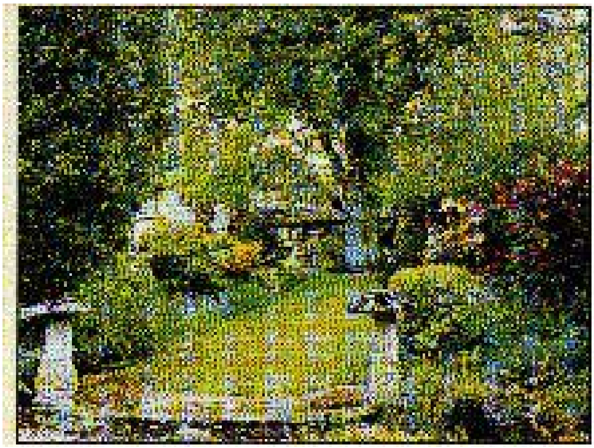
Mynd 32. Óboðnir gestir auka líffræðilegu fjölbreytnina óþægilega mikið!

sögðu rauðsmárinn *(Trifolium pratense).*

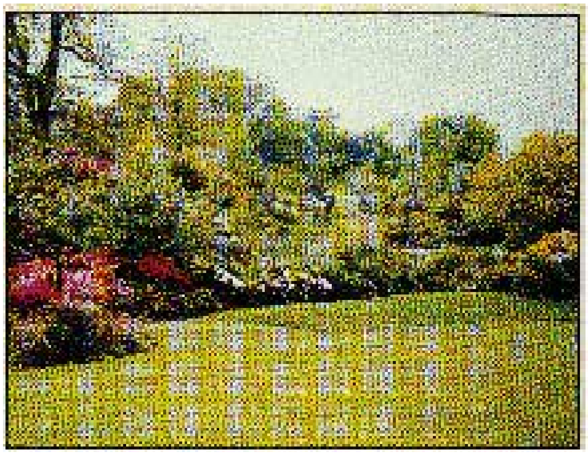
Í ungskóginn hef ég plantað ýmsum harðgerum, fjölærum jurtum, innlendum og erlendum, svo og vorlaukum. Þannig er nú litasýning um allt landið sumarlangt (mynd 29). Ég geri ráð fyrir að þetta verði eitt aðalverkefnið mitt á komandi árum eftir því sem bakið og hnén fara að gefa sig. Og svo getur maður leikið sér að því að koma sér upp steinhæð og „kotgarði" að breskri fyrirmynd (mynd 30). Ég er nú kominn með vísi að einum slíkum í Brekkukoti. Stöðugt litaspil blasir við þegar horft er út um stofugluggann allt vorið, sumarið og jafnvel veturinn líka þegar hrímið leggst á sígræn blöð klettafrúarinnar og fagurfrúarinnar (mynd 31).

Það hefur sem sé orðið töluverð breyting á gróðurfari í Brekkukoti við Hafravatn á þessum 40 árum. Og það þýðir ekki heldur að horfa fram hjá því að það flytja inn fleiri gestir en boðnir eru, sumir ekki sérstaklega þægilegir í nábýli eins og geitungarnir sem hafa tekið sér far með gámaflutningsskipunum og numið hér land, ekki færri en þrjár mismunandi tegundir (mynd 32). En ekki þýðir að fást um það. Líffræðileg fjölbreytni lætur ekki að sér hæða og tegundum jurta, fugla og skordýra er stöðugt að fjölga. Auðnutittlingur og músarrindill eru nýir varpfuglar í landi skógarins í Brekkukoti og rjúpan verpir enn í skjóli grenitrjánna og hefur vetursetu í hópum. Branduglan skýlir sér einnig í grenitrjánum og veiðir hagamýsnar sem lifa veturinn af undir lúpínuteppinu og byggja sér vetrargöng milli matarbirgðanna undir snjónum. Refurinn er orðinn reglubundinn vetrargestur í sömu matföng og branduglan. Rauðhöfðaönd, urtönd og duggönd hafa fundið sér varpland í víðikjarrinu við vatnið auk grágæsar, fiskandar og stokkandar sem þar voru fyrir. Rósastarri söng sumarlangt eitt árið og reyndi að galdra til sín maka. Kerlingin birtist þó aldrei og rósastarrinn sást ekki aftur. Nú bíðum við spennt eftir að glókollurinn og trjáskríkjan komi og taki sér bólfestu.

Mynd31. Hrímbryddaðar fagurfrúr bíða þolinmóðar og grænar eftir vorinu.



Mynd 33. Á Suður-Englandi er líklega lengst reynsla af innflutningi plantna sem prýða umhverfið.



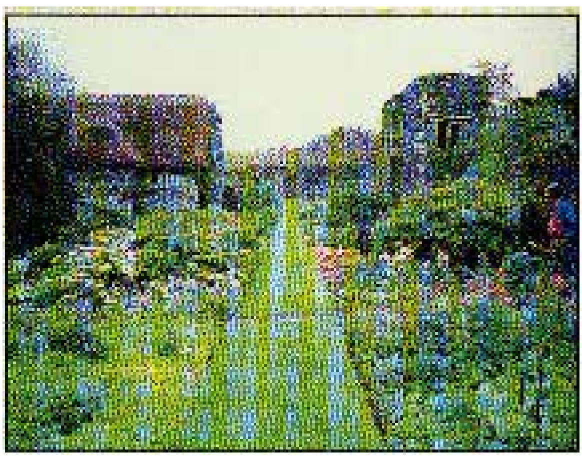
Mynd 35. Garður Lionel Fortescue er ótrúleg uppspretta hugmynda fyrir ræktunarfólk.

Og áhugasviði ræktunarmannsins eru lítil takmörk sett. Ég ætla að enda hér með nokkrum myndum úr garðaskoðun á Suður -Englandi frá vorinu 1999 (myndir 33 og 34). Þær gefa vísbendingu um þá stefnu sem mig dreymir að taka á næstunni. Ég veit að gróðurskilyrðum er ekki saman að jafna og plöntuvalið verður annað en hver veit nema við getum náð ótrúlegum árangri ef við leggjum okkur fram, öflum okkur þekkingar og leitum að heppilegum efniviði. Við erum þegar komin langt fram úr vonum okkar sjálfra frá 1960! En mikilvægt er einnig að velta fyrir sér hvernig nýr gróður fer í landinu og hvernig skipuleggja má garð svo hann samsamist stærra landslagi. Það er nokkuð sem sumarbústaðaeigendur með ræktunaráhuga gætu hugað að. Hvergi er líklega jafngott að fá fyrirmyndir og í Englandi og Skotlandi að þessu leyti. Englendingar hafa langa reynslu af innfluttum plöntum, og landslagshönnun.

Hér fer ég með ykkur lesendur inn í garð sem karlinn hann Lionel Fortescue stofnaði í Suður- Devon á Englandi rétt eftir heimsstyrjöldina. Eins og margir vita var þessi kennari yfirstéttarstráka við Etonskóla mikið við veiðar hér á landi árunum milli 1930-1940 (myndir 35, 36 og 37). Hann er sagður hafa unnið fyrir bresku leyniþjónustuna hér á landi á árunum fyrir stríð og skrifaði víst dreifibréfið til Reykvíkinga sem varpað var úr flugvél yfir Reykjavík hernámsmorguninn 10. maí 1940. Garðurinn hans, sem hann kallaði Garden House, er byggður í rústum gamals klausturgarðs og biskupssseturs, skammt þar frá sem Sir Francis Drake bjó. Það er sannarlega vel þess virði að taka á sig krók ef þið eigið leið um Suðvestur-

Mynd 34. Þar kunna menn að gera fjarlægt landslag að hluta af garði sínum.

Mynd 36. Litir og form skapa frábært jafnvægi.



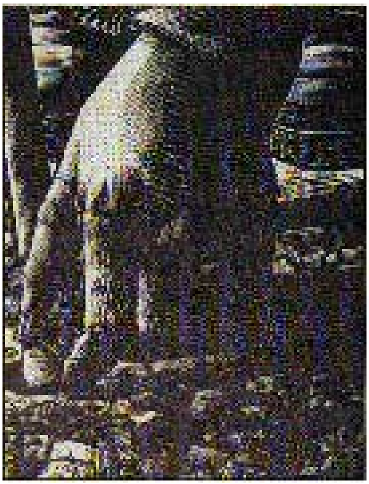
Mynd 37. Blómskrúð sem lýsir í rigningu.

Mynd 38. Og hvað gæti gerst í þessu landi?

England og skoða þennan frábæra garð sem eins og þessar myndir sýna skín í ótrúlegri litadýrð, jafnvel á dumbungsrigningardegi eins og þegar við heimsóttum staðinn. Sjónræn hönnun garðsins er einstaklega áhrifamikil án þess að beitt sé brögðum formklippinga eða manngerðra aðskotahluta. Áhrifin byggjast fyrst og fremst á samsetningu blómlita, laufgerða og á eðlilegum vaxtarformum plantnanna sjálfra og staðsetningu þeirra í landslaginu innan garðsins sem er um 6 ha að stærð. Þarna má m.a sækja hugljómun fyrir skipulag og staðsetningu trjáa og plantna í umhverfinu, - t.d. að sjá fyrir sér íslenskt landslag með nýjum tegundum og samspili trjáa og fjölærra plantna, innlendra og innfluttra. Þá gildir að sjá fyrir sér samspil skapað af fjölbreytni gróðurs, hóflega þéttri plöntun eða vandaðri grisjun, - skjól fyrir mannlíf, en sjónræn áhrif fjalla og landslags í fjarska tekin með í reikninginn. Ný tækni, sýndarveruleiki tölvunnar, gerir okkur meira að segja mögulegt að sjá fyrir hvernig landið verður, hvaða tegundir henta til plöntunar, og hvernig landið lítur út þegar þær eru

Mynd 39. ...ef vel er haldið á spöðunum!

orðnar fullvaxta í því.
Og þá til baka í Brekkukot og heiðina ofan við Þormóðsdal. Þar má þegar njóta vetrarstunda og sumarstunda í nýju umhverfi sem verið er að skapa af mörgum höndum þessi árin (mynd 38). Þar er að verða hljóðlát bylting fyrir áhrif fólks eins og hans Árna Friðjónssonar við Heytjörn sem, eins og hann Elséard Bouffier, fór að planta trjám þar sem engin voru fyrir og enginn trúði að væri hægt. Þetta er þolinmæðisstarf og það reynir á bakið (mynd 39). Það skilar árangri á löngum tíma. Það gerist með því að planta trjám, - einu í einu, - tré fyrir tré - og hlúa vel að! (mynd 40).



Mynd 40. ... með því að planta trjám - einu í einu, - tré fyrir tré - og hlúa vel að!

HEIÐURSÁSKRIFENDUR SKÓGRÆKTARFÉLAGSINS

REYKJAVÍK

Aletli ehf
Almenna verkfræðistofan hf
Árgerði ehf
Bílaleiga AKA
Bílastjarnan sf
Björn og Guðni hf
Björn Traustason ehf
Blómaval ehf
Borgarnesti ehf
Bændasamtök Íslands
Ferðafélag Íslands
Forsætisráðuneyti
Fullorðinsfræðsla fatlaðra
Gagnaeyðing ehf
Garða- og umhverfisþjónustan ehf
Gámaþjónustan hf
Guðmundur Jónasson ehf
Gullkistan
Gunnar Eggertsson hf
H. Bjarg ehf
H.A.C. ehf
H.Hauksson ehf
Hagi ehf
Hringiðan ehf/Vortex Inc.
Hús og ráðgjöf ehf
Ísól ehf
Ístak hf
Jón Júlíus Elíasson
KPMG Endurskoðun hf
Námsflokkar Reykjavíkur
Náttúruvernd ríkisins
Nýi-Sírius hf
NPS innheimtulausnir
Olíufélagið hf
Ólafur Þorsteinsson ehf
Perlan ehf
Plastprent hf
Póstdreifing ehf
Rafmagnsveitur ríkisins
Rafteiknistofan hf
Rannsóknarráð Íslands
Samband íslenskra sveitarfélaga
Samgönguráðuneyti
Samskip hf
Securitas hf
Seðlabanki Íslands
Sigurður I. Sveinbjörnsson
Skeljungur hf
Skógræktarfélag Reykjavíkur
Sólar Hermannsson ehf
Steypustöðin ehf
Stoðtengi sf
Tékk-Kristall ehf
Umhverfisráðuneyti
Ungmennafélag Íslands
Veðurstofa Íslands
Veiðimálastofnun
Verslunarráð Íslands
Vélaleiga Einars H. Péturss. ehf
Vélamiðstöð Reykjavíkurborgar
Vélstjórafélag Íslands
Vinnuskóli Reykjavíkur
Vöruflutningamiðstöðin hf
Þín verslun ehf
Tiffanys Gler Studio
Vélaver
Bílastjarnan
Annáll ehf
Gesthús Dúna hf
Austurleið SBS

SELTJARNARNES

Umhverfisnefnd Seltjarnarness

KÓPAVOGUR

B.S.A. sf
Borgarvirki ehf
Byko hf
Garðyrkja ehf
Jarðbreyting ehf
K.T. Trévirki sf
Kópavogsbær
Kópavogsbær
Ora – niðursuðuverksmiðja hf
P.Samúelsson hf
Prentsmiðjan Viðey ehf
Ömmubakstur ehf
SH bílaleiga

GARÐABÆR

Álverki ehf
Blómaverslunin Garðablómið
Garðabær

HANNES FLOSASON

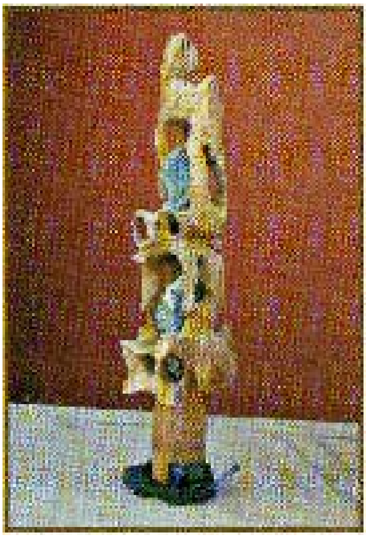
SNORRI KARLSSON tálguskáld

Það telst ekki til tíðinda þótt menn stundi sundíþrótt sér til hressingar. Í heita pottinum taka menn gjarnan tal saman um málefni líðandi stundar. Eitt sinn barst talið að tréskurðarlist og sagðist þá einn pottverja hafa stundað þá listgrein í frístundum um langt árabil. Lauk svo þessari pottdvöl að maðurinn bauð mér að koma og líta á nokkur verka sinna.

Þetta var Snorri Karlsson, tálguskáld, sem býr í Kópavogi. Þegar ég sá verkin, rifjaðist upp fyrir mér sýning, sem haldin var á Kjarvalsstöðum fyrir u.þ.b. 20 árum. Þar voru þá sýnd nokkur af verkum Snorra. Hreifst ég mjög af þeim og hvatti nemendur mína að missa ekki af sýningunni. Engin deili vissi ég þá á Snorra eða listverkum hans.

Tréskúlptúrar Snorra eru frjáls formun í tré, íslenskt birki eða aðrar viðartegundir. Fer einkar vel á því að kalla þetta skáldverk í tré, því að fyrirmyndir notar Snorri ekki, heldur leyfir hugmyndum að streyma í frjálsri formsköpun. Þó alltaf undir ströngum aga og yfirvegaðri smekkvísi. Birtan flæðir í gegnum verkin og ljós og skuggar brotna á hvössum brúnum. Hann nefnir þessa vinnuaðferð spuna, líkt og þekkist í tónlist og leiklist.

Snorri Karlsson í vinnustofu sinni Huldubraut 23, Kópavogi.

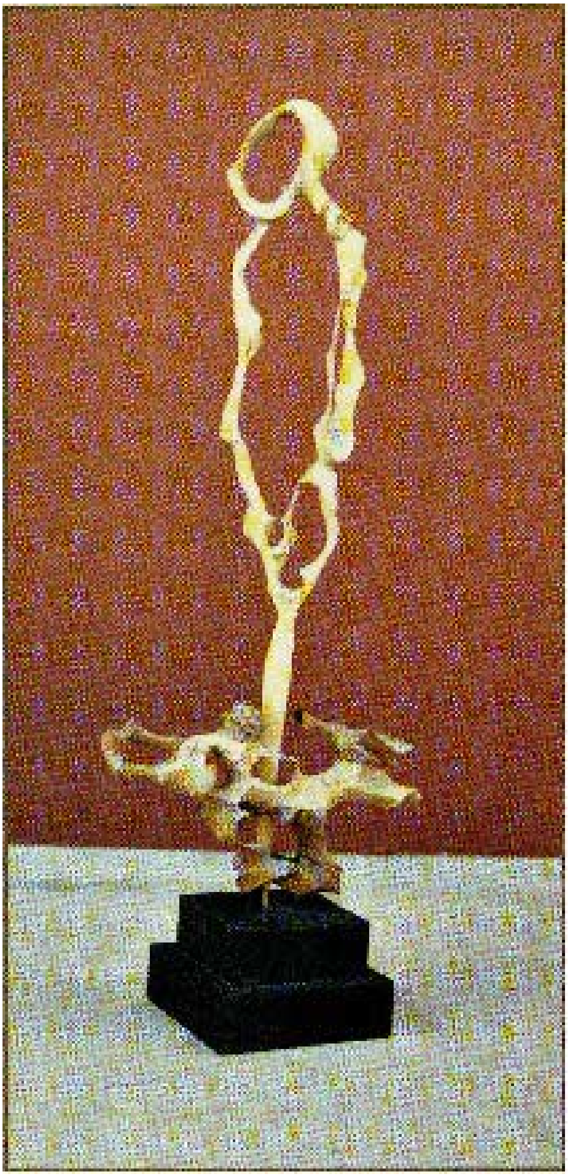


Snorri Karlsson: „Hvítserkur“ í vinnslu. Efni: Tekk.

„Ég var sex ára ,þegar faðir minn gaf mér vasahníf,“ sagði Snorri. „Þá voru aðrir tímar og algengt að drengir á þessum aldri fengju slíkt verkfæri. Svo var fundin spýta og hafist handa við að tálga einhver form úr henni. Síðan hef ég tálgað mér til ánægju, og má segja að spýtan og hnífurinn hafi ekki úr höndum mér fallið eftir það.“

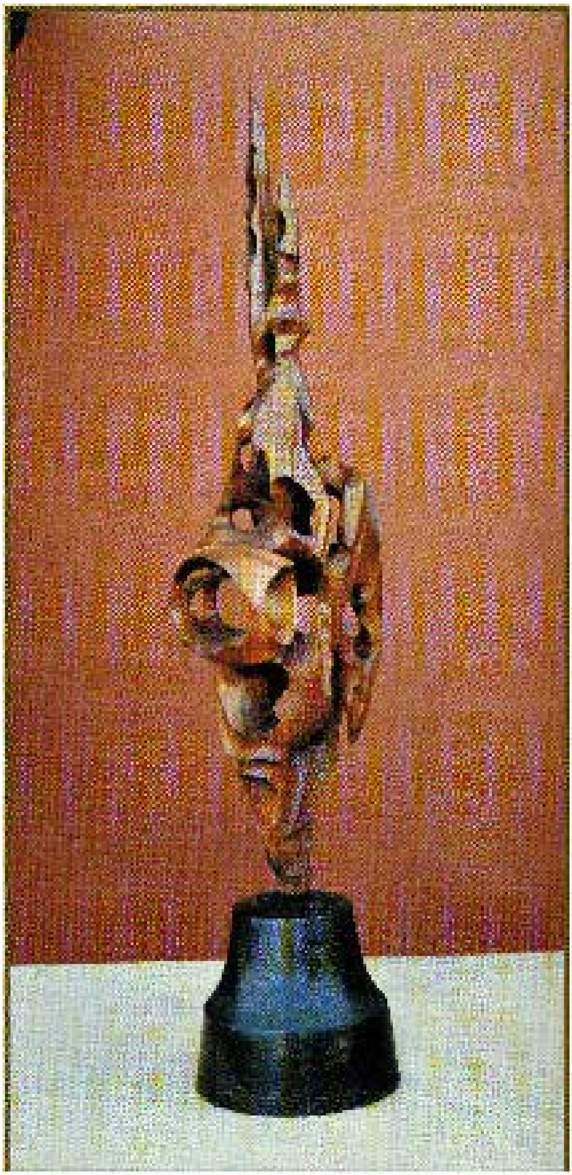
Snorri var svo vinsamlegur að lána mér nokkur verk til að sýna nemendum mínum. Stóðu þau í eina viku á kennsluverkstæðinu og vöktu mikla aðdáun. Var þar mikið spáð og spekúlerað, því að verkin opnuðu fólkinu nýja sýn á möguleikum þess að forma tré.

Eins og sjá má á meðfylgjandi myndum eru skúlptúrar Snorra mjög persónulegir. Sköpunarkrafturinn leynir sér ekki. Skoðun þessara verka vekur áreiðanlega löngun margra til að búa til frjálsa skúlptúra í tré, þótt svona verk séu á fárra færi.

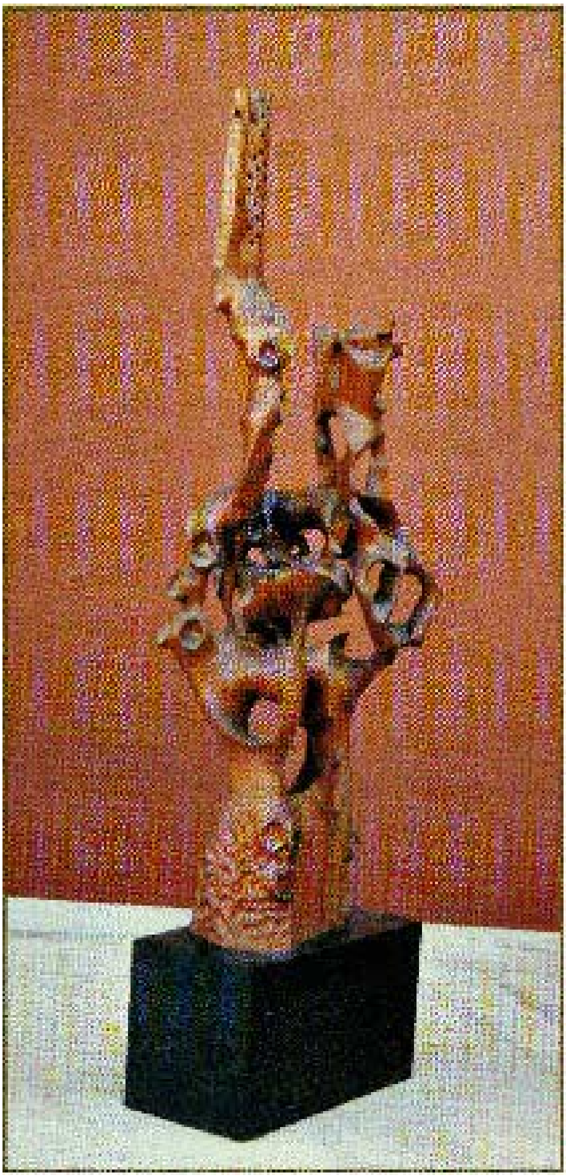


Snorri Karlsson:
„Vofa“ í vinnslu.
Efni: Birki.

Snorri Karlsson:
„Ópið“.
Efni: Birki.



Snorri Karlsson:
„Berserkur“ í vinnslu.
Efni: Tekk.



Snorri Karlsson:
„Hnit“. Efni:
Tekk.

AÐALSTEINN SIGURGEIRSSON

Breytileiki hjá klónum alaskaaspar í næmi gagnvart umhverfi

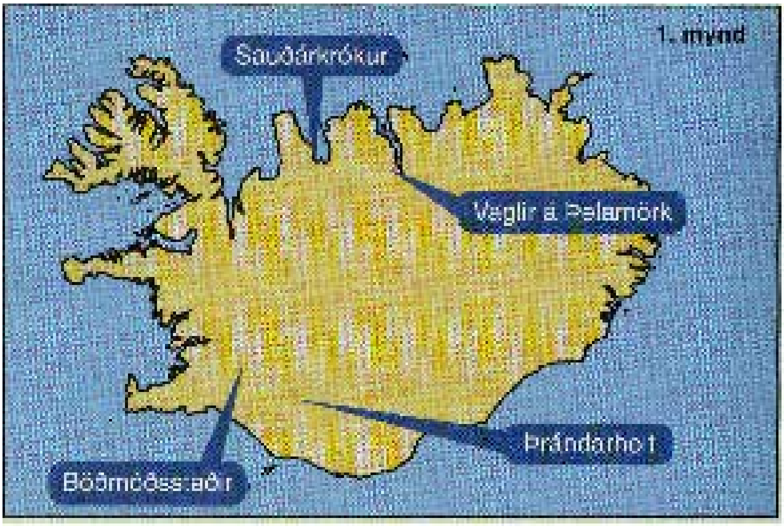
YFIRLIT

Sumarið 1999 var könnuð lifun og hæð meðal 46 asparklóna í samanburðartilraunum sem komið hafði verið á fót á fjórum stöðum á landinu árið 1995. Langtímamarkmið tilraunanna er að bera saman vöxt og þrif mismunandi asparklóna við fjölbreyttar jarðvegs- og veðurfarsaðstæður, og draga af því ályktanir um:

(1) Heppilegt klónaval alaska-aspar fyrir hvern landshluta.
(2) Samspil klóna og umhverfis; m.ö.o. hvort klónaval fyrir eitt hérað skuli vera frábrugðið klónavali í öðrum landshlutum.
(3) Afmörkun fýsilegra ræktunar-svæða einstakra asparklóna.

Tilrauninni var valinn staður á fjórum stöðum; tveimur á Norðurlandi (á Sauðárkróki og Vöglum á Þelamörk) og tveimur í uppsveitum Árnessýslu (Þrándarholti og Böðmóðsstöðum). Á hverjum tilraunastað eru bornir saman allt að 40 klónar alaskaaspar, en á sumum stöðum eru auk þess nokkrir klónar blæaspar teknir með til samanburðar.

Á öllum tilraunastöðum kom fram verulegur og marktækur munur í lifun klóna á fjórða ári frá upphafi tilraunar. Munur milli klóna í hæð var einkum til staðar í tilraunum á Suðurlandi, en þó var hann hvarvetna marktækur. Samspil tilraunastaðar og klóns, í lifun og hæð, var alls staðar marktækt, jafnvel þegar saman voru bornir tilraunastaðir innan sama landshluta. Hvað snerti lifun, var hlutfall breytileikans sem skýrðist af klóni (11,5%) hærra en samspil klóns og staðar (7,5%), og sama var að segja um hæð (4,5 á móti 3,3%). Af því má draga þá ályktun að finna megi klóna sem dafnað geta á öllum tilraunastöðum, en einnig klóna þar sem velgengni þeirra er háð tilraunastað. Klónar sem ættaðir eru frá stöðum sem liggja fjarri strönd Alaska (s.s. klónar frá Kenai Lake og nágrenni) hafa að jafnaði lifað betur en þeir sem ættaðir eru frá strandsvæðum í Alaska.



INNGANGUR

Kvæmi eða klónar trjátegunda sýna oft mikla víxlverkun (samspil) erfða og umhverfis, t.d. þegar slíkir erfðahópar eru gróðursettir þar sem veðurfar er mjög frábrugðið því sem er að finna á upprunastað. Einnig getur mikið samspil erfða og umhverfis komið fram þegar umhverfismisleitni er mikil á upprunasvæðum, svo sem gerist á fjalllendum svæðum (Morgenstern 1996; Namkoong m.fl. 1988; Zobel and Talbert 1984). Þessi víxlverkun getur t.a.m. lýst sér í því að klónn sem reynist vel á einum stað getur reynst ómögulegur við aðrar aðstæður á öðrum stað, og öfugt. Breytileiki í veðurfari er mikill milli og innan héraða á Íslandi, sem aftur ræður miklu um það hve skilyrði eru hér breytileg til skógræktar (Haukur Ragnarsson 1977). Slíkur breytileiki er m.a. talinn ákvarða það hvaða efnivið (tegundir, kvæmi og klóna) er heppilegt að velja til ræktunar í mismunandi landshlutum (Sigurður Blöndal 1977). Nýlegar niðurstöður rannsókna á víðiklónum á Suðurlandi (Aðalsteinn Sigurgeirsson 2000) hafa rennt frekari stoðum undir þá skoðun að þetta eigi við í afar ríkum mæli hérlendis.

Alaskaösp *(Populus trichocarpa* Torr. & Gray) má finna hér á landi að heita má í hvers manns garði, og notkun tegundarinnar fer vaxandi í skjólbeltarækt og skógrækt. Náttúrlegt útbreiðslusvæði hennar er í vesturhluta Norður-Ameríku þar sem hún vex allt frá Alaska í norðri til Kaliforníu í suðri. Líkt og í heimkynnum sínum er hún í Norðvestur-Evrópu meðal þeirra aspartegunda sem hefur hvað mest verið notuð til skógræktar (Jobling 1990; Langhammer 1976; Mühle-Larsen 1976). Tegundin var fyrst flutt inn til Íslands frá Alaska árið 1944 (Jóhann Pálsson 2000; Sigurður Blöndal 1977; Vigfús Jakobsson 1947) og er því áratuga reynsla af veru hennar hérlendis. Síðan hafa margar söfnunarferðir verið farnar vestur um haf (Ágúst Árnason m.fl. 1986; Vilhjálmur Lúðvíksson 1999) og er fjöldi innfluttra klóna og kvæma töluverður.

Langt fram á níunda áratuginn var val aspa til undaneldis hér á landi meira eða minna tilviljanakennt og í besta falli valið eftir kvæmum, en ekki klónum (Jóhann Pálsson 2000). Tegundin hentar vel til klónunar, enda ódýrast að fjölga henni með vetrargræðlingum. Reynslan af mismunandi klónum alaskaaspar innan kvæma er misjöfn, en allt fram til þessa dags hefur vanþekking á eiginleikum einstakra klóna verið Þrándur í Götu árangursríkrar ræktunar alaskaaspar á Íslandi. Klónaval hefur hingað til orðið að byggja að miklu leyti á reynslu og tilfinningu, en hefur ekki stuðst við skipulegar samanburðartilraunir.

Hámarks árangri verður seint náð nema að sá efniviður sem til er í landinu sé vel skilgreindur og eiginleikar mismunandi klóna til ræktunar í mismunandi landshlutum séu vel þekktir. Árið 1990 fékkst styrkur til sex ára á fjárlögum íslenska ríkisins til þess að hefja sérstakt rannsókna- og þróunarverkefni um ræktun alaskaaspar, s.k. „Iðnviðarverkefni“. Verkefninu var ætlað að styrkja forsendur fyrir skilvirkri ræktun asparskóga til timburs og iðnviðar hér á landi. Í tengslum við verkefnið voru gróðursettar á árunum 1992-93 viðamiklar samanburðartilraunir með klóna alaskaaspar á 31 stað víða um land Flestar þeirra klónatilrauna sem lagðar voru út á Norðurlandi og í uppsveitum Suðurlands fóru forgörðum í næturfrosti í ágústmánuði 1993 (sjá Aðalsteinn Sigurgeirsson og Sigvaldi Ásgeirsson 1998). Í kjölfar þess var ákveðið að endurnýja tilraunir í þessum landshlutum á árinu 1995, og verður gerð grein fyrir niðurstöðum síðarnefndu tilraunanna hér. Nánar verður gerð grein fyrir heildarniðurstöðum asparklónatilraunanna 1992-93 síðar og á öðrum vettvangi (Aðalsteinn Sigurgeirsson, Sigvaldi Ásgeirsson og Þórarinn Benedikz, óbirt gögn).

Markmið klónatilraunanna er:

- Að auðvelda val asparklóna fyrir hvern landshluta, með því að finna þá klóna sem lifa vel, vaxa hratt og eru lausir að mestu við veðurfarsskemmdir og sjúkdóma
- Að meta samspil klóna og umhverfis: m.ö.o hvort klónaval fyrir eitt hérað skuli vera frábrugðið klónavali í öðrum landshlutum.
- Að afmarka fýsileg ræktunarsvæði einstakra asparklóna. og renna með því stoðum undir almennt mat á skógræktarskilyrðum, ekki aðeins fyrir alaskaösp, heldur einnig fyrir aðrar trjátegundir.

EFNI OG AÐFERÐIR

Efniviður

Í 1. töflu er að finna helstu upplýsingar um þá klóna sem bornir eru saman í tilrauninni.

Nánari skýringar

Klónar úr söfnunarferðum fyrir 1963: Ellefu klónar, sem allir hafa staðið sig vel um sunnanvert landið, á Akureyri og (eða) á Fljótsdalshéraði. Þessir klónar komu til landsins á 5. og 6. áratugnum, frá svæði á innanverðum Kenai-skaga í Alaska (sk. „Kenai-klónar“). Þeir eru: 'Ey' (nr. 7 í 1. töflu), 'Rein' (nr. 8), 'Sæland' (nr. 14), 'Hallormur' (nr. 17), 'Laugarás' (nr. 18), 'Múli' (nr. 9), 'Grund' (nr. 20), 'P-8' (nr. 29), 'P-2' (nr. 31), 'Randi' (nr. 47) og 'Hringur' (nr. 48).

Klónar úr söfnunarferð Hauks Ragnarssonar til Alaska 1963:
Til er ættbók þeirra klóna sem vitað er um að til eru úr söfnunarferð Hauks Ragnarssonar (Líneik A. Sævarsdóttir & Úlfur Óskarsson 1990). Þar eru skráðir 89 klónar og þeir flokkaðir eftir svipfari (útliti laufblaða, krónulögun,. lit og útliti barkar, breytileika í laufgunar- og lauffallstíma).

Sextán klónar úr þessari söfnun eru teknir með í þessari tilraun:

- Einn, frá Susitna ('C-06'; nr. 46) hefur verið allvinsæll ræktun á norðanverðu landinu sökum frostþols.
- Fjórir eru frá Cordova Flats, en það kvæmi var áður oft skráð eða kallað „C-09“. Þeir eru: 'Pinni' (nr. 5 í 1. töflu), 'Oddný' (nr. 26), 'Linda' (nr. 32), 'Karl' (nr. 36).
- Fimm frá Copper River Delta (frá ósum Koparár), en það kvæmi var oft kallað „C-10“. Þeir eru: 'Iðunn' (nr. 1), 'Brekkan' (nr. 3), 'Keisari' (nr. 15), 'Haukur' (nr. 16) og 'Laufey' (nr. 35).
- Einn frá Dangerous River („C-12“; óskírður. nr. 30), sem er skammt frá Yakutat.
- Einn frá Harlequin Lake („C-13“; 'Depill', nr. 6), sem einnig er nálægt Yakutat.
- Fjórir klónanna eru frá Yakutat („C-14“; 'Salka' (nr. 2), 'Súla' (nr. 5). 'Forkur' (nr. 25) og 'Jóra' (nr. 37).

Klónar úr söfnunarferð Óla Vals Hanssonar og félaga 1985:
Fimm klónar í tilrauninni eru úr Alaskasöfnun Óla Vals Hanssonar og félaga frá 1985; A-415-2 (nr. 9), 'Böðvína' (nr. 10), A-640 (nr. 11), A-674(nr. 12) og 'Sterling' (nr. 13). Þeir eru af tiltölulega norðlægum uppruna og eru taldir helst geta hentað á norðanverðu landinu.

1. tafla. Klónar alaskaaspar sem bornir voru saman í tilraunum 1995.

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2	[illegible]	[illegible]	Yakutat	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
3	[illegible]	[illegible]	Copper River Delta	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	Cordova Flats	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
5	[illegible]	[illegible]	Yakutat	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
6	[illegible]	[illegible]	Harlequin Lake	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
7	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
8	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
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10	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
11	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
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13	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
14	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
15	[illegible]	[illegible]	Copper River Delta	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
16	[illegible]	[illegible]	Copper River Delta	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
17	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
18	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
19	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
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25	[illegible]	[illegible]	Yakutat	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
26	[illegible]	[illegible]	Cordova Flats	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
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[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
32	[illegible]	[illegible]	Cordova Flats	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
35	[illegible]	[illegible]	Copper River Delta	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
36	[illegible]	[illegible]	Cordova Flats	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
37	[illegible]	[illegible]	Yakutat	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
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[illegible]	[illegible]	[illegible]	Copper River Delta	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
50	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
51	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
52	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
53	[illegible]	[illegible]	Copper River Delta	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

1 Samkvæmt kerfi sem lýst er af Líneik Önnu Sævarsdóttur og Úlfi Óskarssyni (1990)
2 Samkvæmt kerfi Jóhannesar Árnasonar (1992)

Klónar sem upphaflega eru fræplöntur, vaxnar upp af fræi af völdum trjám á Akureyri:
Fimm klónanna í tilrauninni eru vaxnir upp af fræi, sem þroskaðist sumarið 1979 á Akureyri og var aðallega tínt við Gilsbakkaveg 11 (nr. 21, 23, 24, 27 og 44 í 1. töflu). Faðirinn mun vera við Gilsbakkaveg 13 (Guðmundur Örn Árnason, munnl. uppl.). Fræplönturnar voru gróðursettar á Mógilsá, og voru valdar þær efnilegustu af nokkrum hundruðum plantna.

Klónar sem upphaflega eru fræplöntur, vaxnar upp af fræi af 'Laufeyju':
Fjórir klónar voru valdir úr hópi nokkurra hundraða fræplantna á Tumastöðum (nr. 22, 34, 39 og 40). Móðir þeirra er 'Laufey' af kvæminu Copper River Delta (C-10), sem stendur í garði Theodórs Guðmundssonar á Hvolsvelli. Tilgangurinn var að fá mat á breytileika sem greina mætti meðal hálfsystkinatrjáa.

Blæösp
Til samanburðar voru valdir nokkrir klónar af blæösp þar af einn íslenskur klónn ('Garðar'), karlkyns klónn frá Garði í Fnjóskadal. Hinir tveir blæasparklónarnir eru frá Skotlandi. Þeir standa sem ung en efnileg tré í trjásafninu á Mógilsá.

Alaskavíðir 'Hríma'
Hríma var tekin með til samanburðar á tveimur tilraunastaðanna.

Allar plöntur sem notaðar voru í tilrauninni voru ræktaðar upp af vetrargræðlingum í gróðrarstöðinni á Mógilsá. Plöntur voru ræktaðar í eitt ár í 150 cm^3 fjölpottabökkum.

Tilraunaskipulag, tilraunaland og framkvæmdalýsing
Notast var við blokkaskipulag, 10 blokkir og fjögur stök af hverjum klón í hverri endurtekningu. Tilviljun réði niðurröðun klóna í hverja blokk. Sömuleiðis var gert sérstakt slembiúrtak fyrir uppröðun á hvern tilraunastað. Bil milli plantna var 2 x 2 m.

Gróðursetning í Þrándarholti og á Böðmóðsstöðum fór fram í ágústbyrjun 1995 en í september á Sauðárkróki og Vöglum á Þelamörk. Fyrr um sumarið hafði tilraunalandið á öllum stöðum verið plægt og tætt Borið var á allar plöntur (30 g af „Blákorni“ á hverja plöntu) á öllum tilraunastöðum vorið 1997, nema á Böðmóðsstöðum þar sem áburðargjöf var sleppt.

Mælingar, athuganir og úrvinnsla
Gerð var heildarmæling á öllum tilraunastöðum í júlí og ágúst 1999. Hæð lifandi plantna vorið 1999 var metin með því að finna efsta stað á hverri plöntu þar sem sproti hafði lifnað út frá brumi um vorið. Mæld var heildarlengd upp að þessu brumstæði, lóðrétt frá jörðu, með 5 cm nákvæmni. Á Sauðárkróki var aðeins 60% tilraunar mæld (6 af 10 blokkum), en á öðrum stöðum var öll tilraunin mæld.

Fervikagreiningu var beitt við úrvinnslu mælinga á hlutfalli lifandi plantna (lifunarhlutfalli) og meðalhæð lifandi plantna í hverjum tilraunareit. Í báðum tilvikum var notuð þáttagreining („factorial analysis“). Til þess var notað tölfræðiforritið SPSS (SPSS for Windows, útg. nr. 90). Fyrir tölfræðiúrvinnslu var lifunarhlutfalli umbreytt í arcsin af kvaðratrót hlutfalls („angular transformation“: Y' = arcsin(Y-½) til þess að dreifni mælinga yrði óháð mæligildum.

NIÐURSTÖÐUR

Lifun
Lifun á fjórða ári frá gróðursetningu var misjöfn eftir tilraunastöðum (Tafla 2) og á öllum stöðum, afar misjöfn eftir klónum. Best var lifun að meðaltali á Böðmóðsstöðum í Laugardal (85%) en síst á Vöglum á Þelamörk (31 %). Niðurstöður fervikagreiningar á lifunarhlutfalli (Tafla 3) leiddi í ljós afar marktækan mun milli staða ($p<0{,}001$), klóna ($p<0{,}001$) og marktækt samspil klóns og staðar ($p<0{,}001$). Þegar skoðað var hvaða einstakir þættir skiptu mestu máli til skýringar á breytileikanum, var staður afgerandi þáttur (40%), því næst klónn (11,5%) og að lokum samspil staðar og klóns (7,5%).

Þegar sömu atriði voru könnuð fyrir hverja tvennd tilraunastaða (Dæmi: Þrándarholti á móti Sauðárkróki; sjá Töflu 5), voru þættirnir „klónn“ og „staður x klónn“ hvarvetna marktækir fyrir lifun. Eins og við var að búast, var röðun klóna á Böðmóðsstöðum og Þrándarholti, sem liggja nálægt hvor öðrum, mjög áþekk. Samspil staðar og klóns var einnig lítillega marktækt (við $\alpha = 0{,}05$) þegar þessir staðir voru bornir saman með tilliti til lifunar.

Á öllum stöðum var greinileg tilhneiging í þá átt að klónar af norðlægari uppruna, svo sem frá nágrenni Kenai Lake, lifðu betur en klónar af suðlægari strandsvæðum, svo sem frá Yakutat eða Copper River Delta (sjá Mynd 2 (a-d)). Tilhneigingin í þessa átt var þó veikust á Sauðárkróki (Mynd 2 (c)). Frá þessu voru þó margar undantekningar, og voru t.d klónarnir 'Forkur' og 'Keisari' víðast hvar í flokki lífvænlegustu klóna.

Hæð
Meðalhæð á fjórða ári var í samræmi við niðurstöður fyrir lifun (Tafla 2); þ.e.a.s. afar misjöfn eftir tilraunastöðum. Aspir á norð-

lensku tilraunastöðunum höfðu vaxið mun hægar en sunnanlands. Engu að síður voru allir sömu þættir og höfðu verið marktækir fyrir lifun (staður, klónn og staður x klónn) einnig marktækir fyrir hæð (Tafla 3). Þrándarholt og Böðmóðsstaðir voru líkastir í hæð, þótt þar kæmi fram marktækt samspil klóns og staðar (Tafla 5).

Þegar bornar eru saman tölur fyrir lifun og hæð á einstökum tilraunastöðum (Mynd 2 (a-d)) sést að samhengi milli lífslíkna og hæðar lifandi plantna er afar lítið. Sömuleiðis sést af 4. mynd að lítið samhengi er milli hæðar sömu klóna á landinu sunnan- og norðanverðu, sem stafar af hægum vexti á norðlensku tilraunastöðunum. Samhengið er hins vegar gott milli sunnlensku staðanna. Klónar af norðlægari svæðum, ásamt nokkrum klónum frá Yakutat ('Súlu', 'Sölku' og 'Forki') voru í hópi hæstu klóna á Böðmóðsstöðum og Þrándarholti (4. mynd).

UMRÆÐA

Tilraun þessi er ung, og getur á þessu stigi ekki gefið nema vísbendingar um klónaval alaskaaspar fyrir mismunandi héruð landsins, þótt á öllum stöðum hafi komið fram verulegur og marktækur munur í lifun klóna.

2. tafla. Lýsing tilraunastaða.

[illegible]

3. tafla. Lifun 33 asparklóna vorið 1999, fjórum árum eftir gróðursetningu á fjórum stöðum árið 1995. Niðurstöður fervikagreiningar og greiningar á dreifniliðum (variance components). Feitletraðar p-tölur tákna þætti sem eru marktækir við α = 0,05. MFS = Meðalfervikasumma. Dreifniliður: „variance component".

Orsök breytileika	Frítölur	MFS	p	Dreifniliður	Skipting dreifniliða
Staðir	3	52,0	**<0,001**	0,1622	39,9%
hlekkir innan stöðva	72	0,5	**<0,001**	0,0093	2,2%
klónn	32	2,0	**<0,001**	0,0469	11,5%
staður x klónn	96	0,4	**<0,001**	0,0311	7,5%
óskýrður breytileiki	1021	0,2		0,1580	38,8%

4. tafla. Meðalhæð 33 asparklóna vorið 1999, fjórum árum eftir gróðursetningu á fjórum stöðum árið 1995. Niðurstöður fervikagreiningar og greiningar á dreifniliðum. Skýringar: sömu og í 2. töflu.

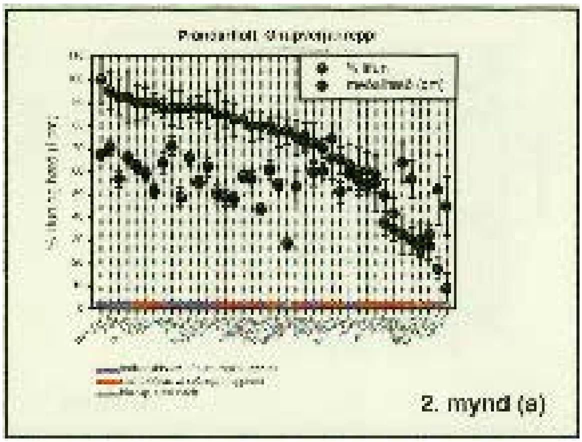
Orsök breytileika	Frítölur	MFS	p	Dreifniliður	Skipting dreifniliða
Staður	3	71563	<0,001	350	68,6%
hlekkir innan stöðva	72	262	**0,001**	4	0,8%
klónn	32	749	<0,001	25	4,9%
staðar x klónn	96	251	<0,001	19	3,3%
óskýrður breytileiki	822	129		170	22,8%

En ef bíða á eftir lokaniðurstöðum langtímarannsókna í skógrækt, þá er víst að biðin verður löng. Um þessar mundir eru upplýsingar um hentugt klónaval fyrir einstaka landshluta mjög eftirsóttar vegna gerðar skógræktaráætlana fyrir einstök héruð (sk. „landshlutabundin skógræktarverkefni"). Hvort sem haldgóðar

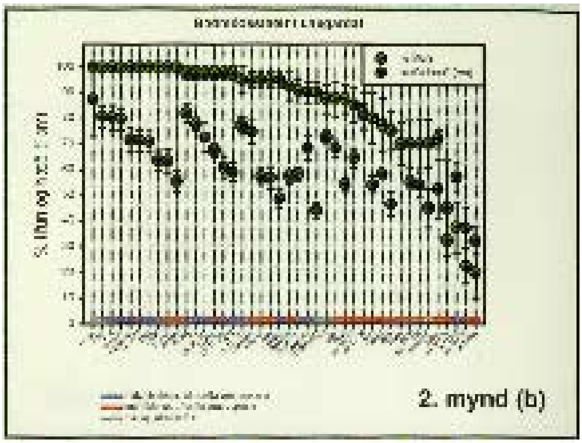
5. tafla. Marktækni klóns og marktækni samspils klóns og staðar í lifun og hæð asparplantna. VC% = % dreifniliðir (variance components).

Lifun 1999 →; meðalhæð 1999 ↓

Staður		Þrándarholt, Gnúpverjahreppi: klónn	Þrándarholt, Gnúpverjahreppi: staður x klónn	Böðmóðsstöðum, Laugardal: klónn	Böðmóðsstöðum, Laugardal: staður x klónn	Sauðárkrók, Skagafirði: klónn	Sauðárkrók, Skagafirði: staður x klónn	Vögum, Fnjóskadal: klónn	Vögum, Fnjóskadal: staður x klónn
Þrándarholt	p	(<0,001)	(<0,001)	<0,001	0,028	<0,001	<0,001	<0,001	<0,001
	VC (%)			32,4	2,5	4,7	11,2	9,2	6,8
Böðmóðsstaðir	p	<0,001	0,028	(<0,001)	(<0,001)	<0,001	<0,001	<0,001	<0,001
	VC (%)	28,6	4,7			3,2	9,3	6,8	6,6
Sauðárkrókur	p	<0,001	[illegible]	<0,001	<0,001	(<0,001)	(<0,001)	<0,001	0,003
	VC (%)	4,7	3,8	5,6	6,8			1,4	7,5
Vogar	p	<0,001	[illegible]	[illegible]	<0,001	[illegible]	[illegible]	(<0,001)	(<0,001)
	VC (%)	7,8	5,5	3,2	4,7	1,5	0,5		



2. mynd (a)

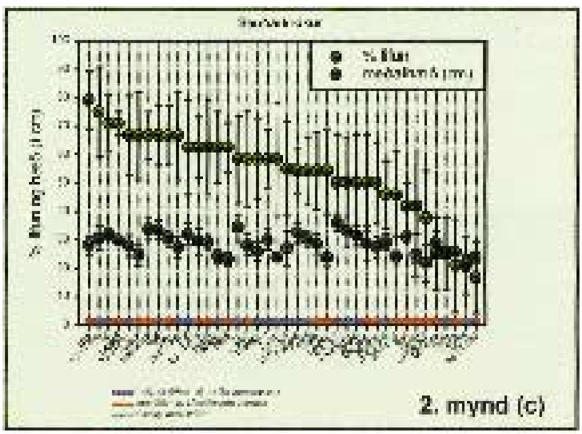


2. mynd (b)

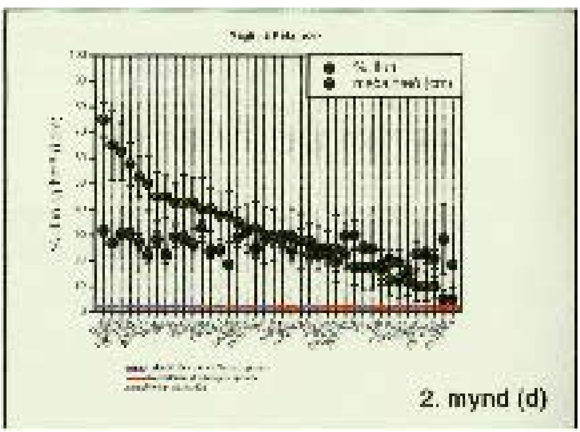
niðurstöður um klónaval liggja fyrir eða ekki, verður á næstu árum farið af stað með umfangsmikla asparskógrækt í þessum héruðum. Því er réttara að hafa þessar niðurstöður til hliðsjónar fremur en að láta aðeins kylfu ráða kasti í klónavali.

Á þessu stigi er ekki réttlætanlegt að nota niðurstöðurnar til annars en að útiloka óhæfa klóna úr ræktun, og vara ber við því að nota þær til þess að velja úr aðeins þá klóna sem skipa efstu sæti. Reynslan af þeim asparklónatilraunum sem hófust 2-3 árum fyrr (Aðalsteinn Sigurgeirsson m.fl., óbirt gögn) sýna að mikill áramunur getur verið í vexti og áföllum hjá einstökum klónum í ungum tilraunum, þannig að þegar tölur eru bornar saman milli ára verða oft „hinir síðustu fyrstir og hinir fyrstu síðastir“. Þessu til viðbótar er enn óútkljáð hvernig asparryðið kemur til með að leika einstaka klóna á næstu árum, þótt fyrstu vísbendingar liggi nú fyrir (sjá grein Guðmundar Halldórssonar m.fl. í þessu riti).

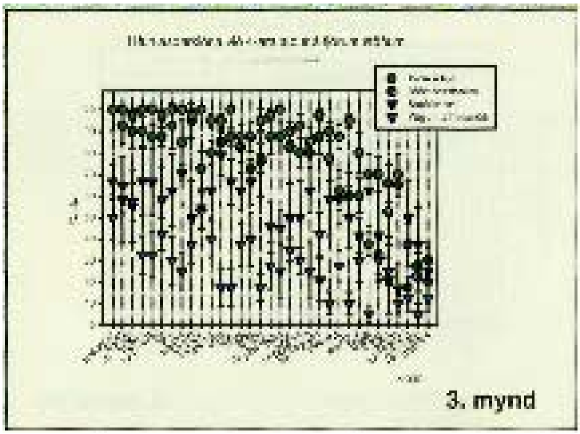
Allir tilraunastaðirnir (nema Sauðárkrókur) liggja fjarri sjó, á svæðum þar sem hætta á næturfrostum á vaxtartímanum er veruleg. Á þremur tilraunastaðanna (Þrándarholti, Böðmóðsstöðum og Vöglum) kom fram að klónar sem ættaðir eru frá stöðum sem liggja fjarri strönd Alaska (s.s. klónar frá Kenai Lake og nágrenni) hafa, að jafnaði, lifað betur en þeir sem ættaðir eru frá strandsvæðum í Alaska. Sennilegasta skýring þess er sú að klónar, ættaðir frá strandsvæðum í Alaska (Copper River Delta, Cordova Flats og Yakutat), eru líklegastir til að leggjast seint í dvala og skemmast af haustkali. Það er hins vegar ekki loku fyrir það skotið, að eftirlifandi plöntur sömu klóna eigi með tímanum eftir að taka sig á í vexti, þegar þeir ná að vaxa upp úr hitaskiptalaginu næst jörðu, þar sem hættan á næturfrostum er mest. Varhugavert er að yfirfæra þessar niðurstöður á þau héruð sem liggja nær sjó. Í samanburðartilraunum með víðiklóna á vetrarmildari svæðum kemur í ljós allt önnur röðun klóna en t.d. í Þrándarholti (sbr. Aðalsteinn Sigurgeirsson 2000). Sama kemur



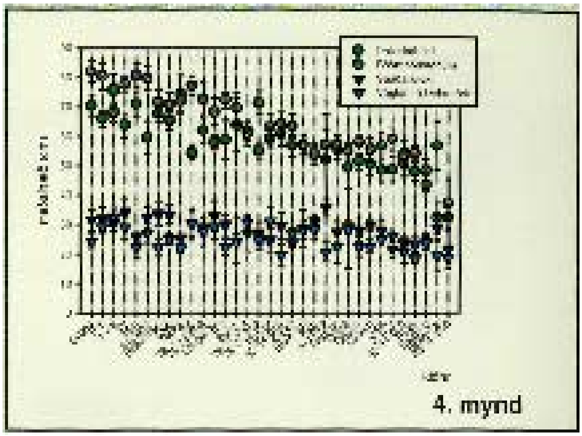
2. mynd (c)



2. mynd (d)



3. mynd



4. mynd

í ljós þegar skoðuð eru gögn úr asparklónatilraununum frá 1992- 93 (Aðalsteinn Sigurgeirsson m.fl., óbirt gögn).

Samspil tilraunastaðar og klóns, í lifun og hæð, var alls staðar marktækt, jafnvel þegar saman voru bornir tilraunastaðir innan sama landshluta. Þessar niðurstöður eru í samræmi við það sem áður hefur komið í ljós á vesturströnd Bandaríkjanna. Þar sýnir alaskaösp tiltölulega mikla víxlverkun milli staðar og klóns miðað við aðrar trjátegundir, sem taka verður tillit til við klónaval (Rogers m.fl. 1988). Hvað snertir lifun, var hlutfall breytileikans sem skýrðist af klóni (11,5%) hærra en samspil klóns og staðar (7,5%), og sama var að segja um samsvarandi tölur fyrir hæð (4,5 á móti 3,3%). Af því má draga þá ályktun að finna megi klóna sem dafnað geta á öllum tilraunastöðum, en einnig klóna hverra velgengni er háð staðarvali. Mikilvægt er í framtíðinni að beina leitinni að þeim klónum sem eru „stöðugir“ (áreiðanlegir) og sýna ekki miklar sveiflur í aðlögun milli staða. Einnig er vert að leggja aukna áherslu á kynbætur sem miða að bættri aðlögun (sbr. Aðalsteinn Sigurgeirsson og Þorbergur Hjalti Jónsson 1999), t.d. með því að sameina mismunandi eiginleika og kosti „norðlægra innlandsklóna“ og „suðlægra strandkvæma“ í afkvæmahópum

ÞAKKARORÐ

Höfundur vill þakka jarðeigendum að Þrándarholti, Böðmóðsstöðum, Sauðárkrók og Vöglum á Þelamörk fyrir afnot af landinu til tilrauna og margháttaða aðstoð við undirbúning þeirra. Sigvaldi Ásgeirsson, Þórarinn Benedikz og Árni Bragason fá þakkir fyrir þátt sinn í skipulagningu og undirbúningi verkefnisins. Þórður Jón Þórðarson og Karl S. Gunnarsson sáu um gróðursetningu, og Karl hafði umsjón með gagnaöflun. Fyrir það fá þeir bestu þakkir. Rannsóknir þær sem hér segir frá voru styrktar af sérstakri fjárveitingu á fjárlögum íslenska ríkisins, til s.k. „Iðnviðarverkefnis“. Ingvar Helgason hf. styrkti gagnaöflun í sambandi við verkefnið.

SUMMARY

Data from a four-year old, four-location clonal trial, comprising in total 46 clones of black cottonwood *(Populus trichocarpa* Torr, & Gray), was analysed to verify and quantify locations x clones interaction and to identify superior clones on the basis of survival and height growth. At all sites (two in north- and two in south-Iceland), there were large and significant differences between clones in survival. Differences in height between clones were low, though highly significant. Locations x clones interaction was significant for survival and height even when examined on a pair-wise basis between sites that were geographically close. Variance components for survival were 11,5% and 7,5%, respectively, for clones and location x clones interaction, and for height they were 4,5 and 3,3%. The results suggest that although GEI interaction is an important consideration for the management of the genetic resources of black cottonwood in Iceland, it is possible to select clones with high survival, growth and genotypic stability. Clones derived from inland and transition areas in Alaska (viz. Kenai Peninsula) performed better in these trials than clones from coastal areas of South Alaska, which is probably due to the trial sites being prone to radiative frost damage during the growing season.

HEIMILDIR

Aðalsteinn Sigurgeirsson. 2000. Samanburður á klónum víðitegunda og undirbúningi jarðvegs við ræktun skjólbelta á Suðurlandi. Skógræktarritið 2000,1. tbl.: 101-114.

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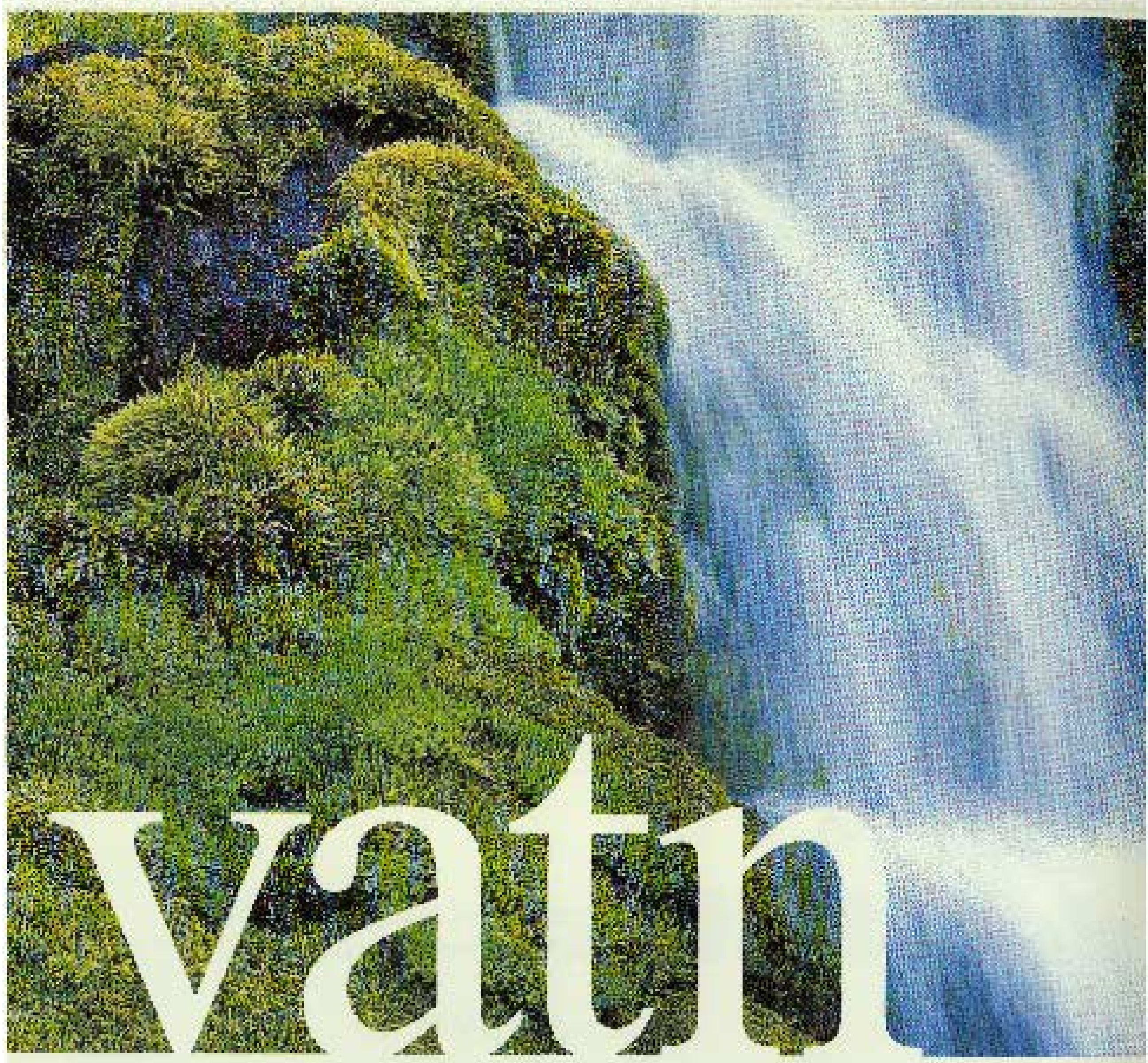

vatn

Frá opnun sýningarinnar Skógur og skógarmenn á Akureyri. Frá V.: Sigurður Blöndal, Óskar Sigurðsson, formaður Skógræktarfélags Árnesinga, Magnús Jóhannesson, formaður Skógræktarfélags Íslands, Guðni Ágústsson landbúnaðarráðherra og Gísli Gestsson.

Skógur og skógarmenn

Inngangur

Það mun líklega hafa verið fyrir um einu ári að við áttum tal saman Sigurður Blöndal og ég. Vorum þá eins og endranær að ræða um efni í Skógræktarritið enda oft ærið tilefni til. Sjálfsagt hefur það ekki farið fram hjá vökulum augum lesenda að Sigurður er okkar helsti burðarás í skrifum ritsins. Virðist hann frekar færast í aukana eftir því sem árin líða og eys þar af sínum ótæmandi viskubrunni og fróðleik og gerir það á svo skemmtilegan og aðgengilegan hátt að allir hafa bæði gagn og gaman af.

En auðvitað vorum við ekki að ræða um þetta, heldur barst aðalfundur Skógræktarfélags Íslands í tal sem þá hafði verið ákveðið að halda á Akureyri. M.a. var fitjað upp á því að gaman væri að draga fram í dagsljósið andrúmsloft fyrri aðalfunda Skógræktarfélags Íslands með myndum og texta. Hugmyndin blundaði með okkur fram á vor og var borin undir stjórn félagsins þar sem hún fékk góðar undirtektir.
Þegar fundur félagsins á Akureyri nálgaðist sl. sumar ráðfærðum við okkur við Gísla Gestsson í Ljósmyndavörum sem hefur áratuga reynslu af ljósmyndun og kvikmyndagerð og hefur reynst mikill velgjörðamaður skógræktarmálefnisins.

Niðurstaðan varð í stuttu máli að til varð tvíþætt sýning ljósmynda Sigurðar Blöndals frá fyrri aðalfundum félagsins og hins vegar myndir Gísla Gestssonar og C.E. Flensborgs frá Hallormsstað. Sýningin var sett upp á aðalfundi félagsins á Akureyri í ágúst sl. Ljósmyndavörur ehf. kostaði uppsetningu sýningarinnar, stækkanir og myndvinnslu og víst er að án þess velvilja hefði sýningin ekki orðið að veruleika. Sýningin vakti mikla athygli fundarmanna og því fannst ritstjóra Skógræktarritsins við hæfi að gefa lesendum kost á að sjá smásýnishorn af myndum, sem prýddu afmælisfund félagsins

Ritstjóri

Hallormsstaður árið 1903 og árið 2000

Stækkaðar voru myndir sem Christian E. Flensborg tók á Hallormsstað 1903. Gísli Gestsson tók svo myndir á gleiðhorni af sömu stöðunum við sama sjónarhorn. Þannig má sjá hvernig landslag Hallormsstaðar hefir breyst á nærri heilli öld. Til þess að ná sumum yfirlitsmyndanna þurfti sérstakan bíl með stólalyftu.

Horft niður til Markarinnar af Selvegi. Kerlingará á miðri mynd. Efri myndin er tekin árið 1903 en neðri myndin í ágúst árið 2000.

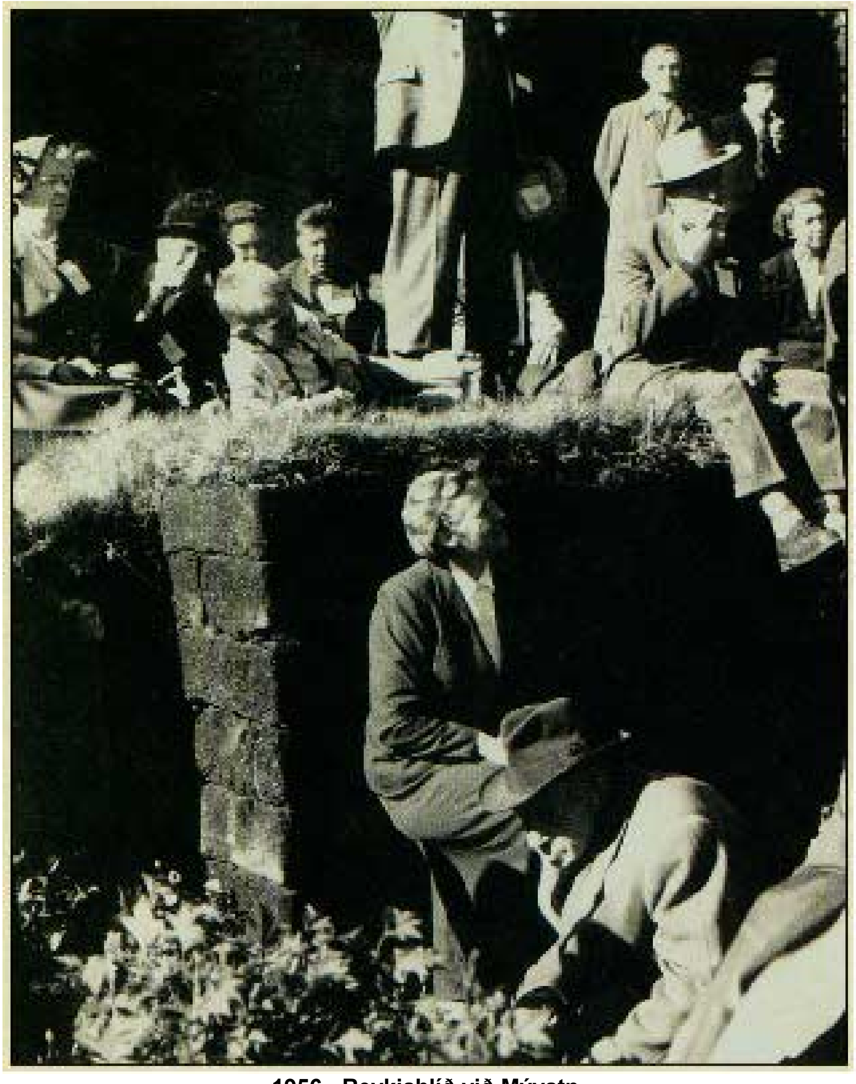
Efri mynd: Neðst í Mörkinni árið 1903. Neðri mynd: Síðdegissól í Mörkinni í ágúst árið 2000.

Hallormsstaðarbærinn. Efri myndin tekin árið 1903 en neðri myndin í ágúst árið 2000.

Norðausturhorn Markarinnar. Efri mynd er tekin árið 1903 en neðri myndin í ágúst árið 2000.

Svipmyndir frá aðalfundum Skógræktarfélags Íslands árin 1956-1998

Sigurður Blöndal tók gjarnan allmikið af myndum, er hann sat aðalfundi félagsins. Hér er sýnishorn úr myndasafni hans.



1956 - Reykjahlíð við Mývatn ,
Á Höfða við Mývatn.
Frú Guðrún Pálsdóttir, eigandi Höfða, á miðri mynd. Framan við hana situr Agner Kofoed-Hansen, fyrsti skógræktarstjóri á Íslandi (með hatt). Þetta er líklega eina myndin af honum, sem til er, á aðalfundi Skógræktarfélags Íslands.

1968 - Hallormsstaður
Við Guttormslund í Hallormsstaðaskógi. Fundarmenn þiggja hressingu að lokinni skoðun. Þekkja má (frá vinstri): Odd Andrésson, Neðra-Hálsi í Kjós, Guðbrand Magnússon, Reykjavík, Ingigerði ??, s.st., Ragnar Jónsson, s.st., Svein Jónsson, Egilsstöðum á Völlum, Halldór Sigurðsson, Miðhúsum í Eiðaþinghá, Hálfdán Sveinsson, Akranesi, Hauk Jörundarson, Reykjavík, stjórnarmann Skf. Íslands, Guðmund Marteinsson, Reykjavík, stjórnarform. Skf. Reykjavíkur, Vilhelm Elgrud, framkvstj. Norska skógræktarfélagsins, Ólaf Jónsson, Selfossi, form. Skf. Árnesinga, Garðar Jónsson skógarvörð, Selfossi og Sigurð Jónasson skógarvörð, Varmahlíð, Skagafirði.

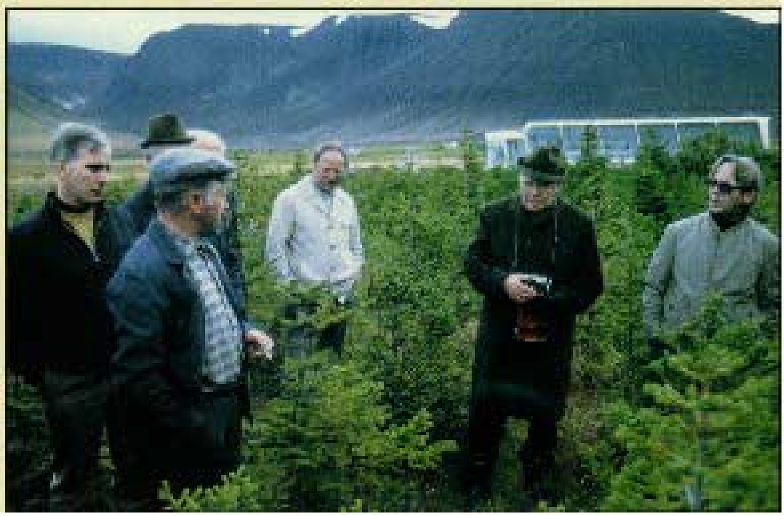
1969 - Stykkishólmur
Fundarmenn ganga á land í Klakkeyjum. Flóabáturinn Baldur flutti þá þangað.

1970 - Akureyri

Hópmynd tekin í Vaglaskógi.
Ekki er kostur að nefna nöfn, nema undantekningu verður að gera um Jón Rögnvaldsson, garðyrkjumann á Akureyri, sem gekkst fyrir stofnun hins fyrsta Skógræktarfélags Íslands á Akureyri 13. maí 1930. Nafni þess var breytt Í Skógræktarfélag Eyfirðinga, er annað hafði verið stofnað á Þingvöllum 27. júní sama ár. Jón Rögnvaldsson er þriðji frá hægri Í öftustu röð. Ljósmyndari óþekktur, en myndin er tekin á myndavél Sigurðar Blöndal.

1971 - Hafnarfjörður

Í gróðurhúsi Rannsóknastöðvarinnar á Mógilsá. Haukur Ragnarsson, forstöðumaður stöðvarinnar, skýrir frá græðlingarækt í húsinu.



1974 - Núpur í Dýrafirði

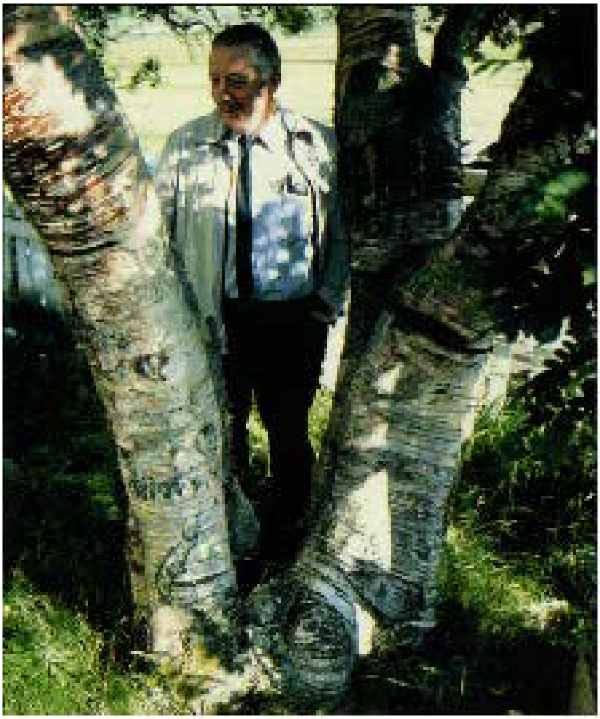
Í sitkagrenireit Þorvalds Zóphoníassonar á Læk í Dýrafirði.
Frá vinstri: Garðar Jónsson skógarvörður, Selfossi, Kristinn Skæringsson skógarvörður, Kópavogi, Þorvaldur Zóphóníasson, Ólafur Vilhjálmsson, Hafnarfirði, Hákon Bjarnason skógræktarstjóri og Lárus Blöndal, Reykjavík.

1980 - Þingvellir

Í Stekkjargjá á Þingvöllum.
Kristján Eldjárn, forseti Íslands, flytur ávarp.

1981 - Egilsstaðir

Í Mörkinni á Hallormsstað.
Þórarinn Þórarinsson frá Eiðum var um langt árabil söngstjóri á aðalfundum Skf. Íslands. Hér taka fundarmenn hressilega undir á flötinni við starfsmannahús skógræktarinnar.



1982 - Akureyri
Við Grundarkirkju í Eyjafirði.
Tveir sterkir stofnar: Ragnar Olgeirsson og ævagömul björk.

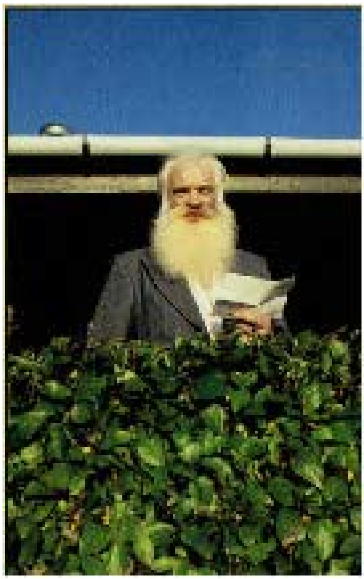
1983 - Sælingsdalslaug í Dalasýslu
Fremsta röð frá vinstri: Pétur Þorsteinsson, sýslumaður Dalamanna, Ásgeir Bjarnason í Ásgarði, fyrrv. alþingismaður, Jón Helgason landbúnaðarráðherra, Hákon Bjarnason fyrrv. skógræktarstjóri, frú Guðrún Bjarnason.
Önnur röð frá vinstri: Ingólfur Sigurgeirsson frá Stafni í Reykjadal, Jón Pálsson form. Hins íslenska garðyrkjufélags, frú Sigurveig Erlingsdóttir, Reykjavík, Tryggvi Sigtryggsson frá Laugabóli í Reykjadal, Kjartan Sveinsson, Reykjavík, Sveinbjörn Njálsson, Hólum í Hjaltadal. Ljósmynd: Jónas Jónsson.

1989 - Ísafjörður

í Tungudal.
Ágúst Árnason, skógarvörður í Hvammi, Skorradal, leiðbeinir nokkrum fundarmönnum um gróðursetningu landgræðsluskóga, sem áformaðir voru vorið 1990.
Hér má m.a. þekkja (frá vinstri) Herdísi Þorvaldsdóttur, formann samtakanna Líf og land, Jón Bjarnason, Hólum í Hjaltadal, Ingibjörgu Kolka, s.st., Odd Sigurðsson, Ytri-Fellsöxl, Skilmannahreppi, Vilhjálm Sigtryggsson, Reykjavík, Reyni Vilhjálmsson, Reykjavík, og Þórunni Eiríksdóttur, Kaðalsstöðum, Stafholtstungum.

1990 - Flúðir

Á Álfaskeiði í Hrunamannahreppi. Hér er hinn frægi skógarreitur Umf. Hrunamannahrepps.
Vigdís forseti er hér með norrænu gestunum á fundinum: Marrku Rauhalati, framkvæmdastjóra Finnska skógræktarfélagsins (t.v.) og Oluf Aalde, skógræktarstjóra Noregs (t.h.). Aalde var kjörinn heiðursfélagi Skf. Íslands á aðalfundinum 1999.



1991 - Höfn í Hornafirði
Í Karlsfelli í Lóni.
Sveinbjörn Beinteinsson allsherjargoði flytur fundarmönnum dýrt kveðna drápu af svölunum á sumarbústað Ásgríms og Guðrúnar konu hans.

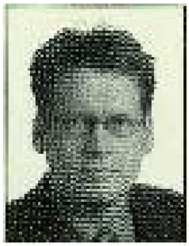
1993 - Húsavík
Við Skógarhús Skógræktarfélags Suður-Þingeyinga í Fossselsskógi.
Hulda Valtýsdóttir, form. Skf. Íslands, afhendir Friðgeiri Jónssyni, Ystafelli, gjöf. Hólmfríður Pétursdóttir, Reynihlíð, form. Skf. Suður-Þingeyinga, er við hliðina á þeim, en Halldór Blöndal landbúnaðarráðherra og Jónas Jónsson búnaðarmálastjóri og fyrrv. form. Skf. Íslands eru á bak við.

1994 - Kirkjubæjarklaustur
Undir Melhól á Stjórnarsandi. Nærmynd af hluta fundarmanna, sem slökkva þorstann með Beck's bjór í boði Karls Eiríkssonar.

1995 - Egilsstaðir
Í Atlavíkurlundi, Hallormsstað.
Jón Loftsson skógræktarstjóri skýrir fundarmönnum, meðal þeirra Davíð Oddssyni forsætisráðherra, frá því, að nú verði mælt hæsta tréð í lundinum, sem líklega hafi náð 20 m hæð, fyrst trjáa á Íslandi.

1997 - Núpur í Dýrafirði
Í Botnsskógi í Dýrafirði, útivistarskógi Skf. Dýrfirðinga.
Fundarmenn hlýða á leik fjögurra valinkunnra nikkara á meðan þeir njóta veitinga.




GUÐMUNDUR HALLDÓRSSON, GUÐRÍÐUR GYÐA EYJÓLFSDÓTTIR,
EDDA SIGURDÍS ODDSDÓTTIR,
AÐALSTEINN SIGURGEIRSSON OG HALLDÓR SVERRISSON

Viðnámsþróttur alaskaaspar gegn asparryði

Inngangur

Asparryð, sem asparryðssveppurinn *Melampsora larici-populina* Kleb. veldur, er algengur sjúkdómur á ösp í Evrópu en hefur borist þaðan víðar, m.a. til Ameríku, Ástralíu og Nýja Sjálands. Á þessum svæðum hefur hann dregið verulega úr vexti aspa og í einstaka tilvikum drepið tré. Mest hefur tjónið verið í Niðurlöndum, Frakklandi og Ítalíu þar sem eru ræktaðir blendingar evrópskra og amerískra aspa. Hér varð þessa sjúkdóms fyrst vart um mitt sumar 1999. Ekki er vitað með vissu hvernig hann hefur borist til landsins né hvaðan. Þó benda erfðafræðirannsóknir til þess að hann hafi komið frá norðanverðum Bretlandseyjum og er þá óneitanlega líklegast að hann hafi borist hingað með vindi.
Í því sambandi má benda á að talið er að asparryð hafi borist með vindi frá Ástralíu til Nýja-Sjálands. Asparryðið olli töluverðum skemmdum á ösp í Hveragerði og á Selfossi síðsumars 1999 (1. mynd) og í kjölfar þess var nokkuð um kal á öspum veturinn 1999-2000 (2. mynd). Síðast liðið sumar breiddist ryðið út á Selfossi og einnig varð þess vart neðst í Grímsnesi og í Þorlákshöfn. Þetta hefur valdið trjáræktendum töluverðum áhyggjum og ekki bætir úr skák að fleiri sjúkdómar hafa verið að skjóta hér upp kollinum að undanförnu. Nú er verið að rannsaka þessa sjúkdóma og leita leiða til úrbóta. Þátttakendur í því starfi eru sérfræðingar frá Náttúrufræðistofnun Íslands, Rannsóknastofnun landbúnaðarins, Rannsóknastöð Skógræktar ríkisins, garðyrkjustjóri Reykjavíkurborgar, umhverfisstjórar Árborgar og Hveragerðis auk forsvarsmanna Landshlutabundinna skógræktarverkefna.

Unnið hefur verið að þremur meginmarkmiðum. Í fyrsta lagi að ákvarða útbreiðslu og skaðsemi trjásjúkdóma hér á landi. Í öðru

1. mynd. Ösp á Selfossi illa skemmd af ryðsjúkdómi haustið 1999. Innfelld er stækkuð mynd af skemmdum blöðum. Mynd: H.S.

2. mynd. Toppkalin ösp í Hveragerði sumarið 2000. Mynd: H.S.

3. mynd. Lerkitré rétt ofan Svartagilshvamms í Haukadal stórskemmd af nálafallssýki og lerkiátu. Tré í þessum reit eru af kvæminu Hakaskoja, en það kvæmi hefur víða fengið slæma útreið af völdum sjúkdóma. Mynd: H.S.

lagi að leita úrlausna á þeim vanda sem skapast hefur þar sem aspar- og gljávíðiryð hefur geisað hvað harðast. Í þriðja lagi að finna klóna af ösp og gljávíði sem hafi nægan viðnámsþrótt gegn ryðsjúkdómum. Fyrstu niðurstöður úr rannsóknum á viðnámsþrótti asparklóna liggja nú fyrir og verða kynntar hér. Fyrst verður þó drepið lauslega á aðra þætti þessara rannsókna, en þeim verða gerð betri skil síðar.

Útbreiðsla trjásjúkdóma. Rannsóknir á útbreiðslu trjásjúkdóma hafa verið mjög óreglulegar hér á landi. Upphaf þeirra má telja ferð Helgu og Finns Roll-Hansen sumarið 1969. Finn Roll-Hansen fór síðan í annan leiðangur sumarið 1989. Sumarið 1993 var útbreiðsla sjúkdóma á landinu könnuð á ný, auk þess sem sérstök úttekt var gerð á skemmdum í Hallormsstaðaskógi og nágrenni.

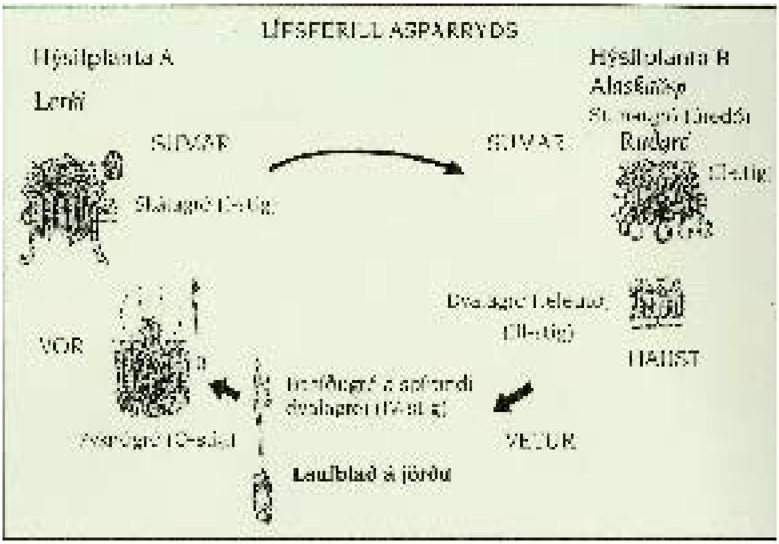
Fram undir lok níunda áratugarins voru helstu trjásjúkdómar hér á landi taldir vera barrviðaráta (*Phacidium coniferarum*), brum- og greinaþurrksveppur (*Gremeniella abietina*), reyniáta (*Cytospora rubescens*) og ryðsveppir á víði (*Melampsora epitea*) og birki (*Melampsora betulinum*). Síðan hefur komið í ljós að lerkiáta (*Lachnellula willkommii*) er útbreidd um landið og veldur verulegum skakkaföllum á lerki sunnan lands og vestan. Á tíunda áratugnum varð veruleg breyting til hins verra. Sumarið 1994 uppgötvaðist gljávíðiryð (*Melampsora larici-pentandra*) á Höfn í Hornafirði. Sá sjúkdómur hefur nú borist allt vestur á Akranes. Árið 1998 greindist þináta (*Phacidium balsamicola*) í fjallaþin á Hallormsstað en sá sjúkdómur virðist raunar vera búinn að vera hér alllengi og víða um land. Sumarið 1999 bættust síðan fjórir nýir sjúkdómar við: greniryð (*Chrysomyxa abietis*), greninálafallssýki (*Rhizosphaera kalkoffii*), lerkinálafallssýki (*Meria laricis*), og asparryð. Sá síðastnefndi er væntanlega nýkominn til landsins en líklegt er að hinir þrír séu búnir að vera hér eitthvað lengur. Til dæmis mátti greinilega rekja á skemmdum á rauðgreni í Leirárgirðingu í Leirársveit að þangað hefði greniryð borist ekki síðar en árið 1997. Útbreiðsla þessara sjúkdóma á Suðurlandi var könnuð haustið 1999 og hafa niðurstöðum þeirrar könnunar þegar verið gerð skil í Skógræktarritinu. Síðast liðið sumar var síðan farið um land allt og útbreiðsla trjásjúkdóma könnuð. Niðurstöðum þeirrar könnunar verða væntanlega gerð skil í næsta hefti Skógræktarritsins.

Skaðsemi trjásjúkdóma. Sumarið 1999 var reynt að meta skemmdir á lerki í Haukadal eftir nálafallssýkina sem þar geisaði í fyrrasumar. Þessar skemmdir eru raunar fyrst og fremst kalskemmdir sem orsakast af því að sjúkdómurinn hindrar lerkið í að búa sig nægilega vel undir veturinn líkt og gerist í kjölfar ryðs á ösp og gljávíði. Ekki hefur enn verið unnið að fullu úr þeim niðurstöðum en nokkuð virðist vera um að tré hafi drepist eða stórskemmst af völdum nálafallssýkinnar. Skaðinn virtist vera mestur á yngri trjám, en einnig eru dæmi um að 50-60 ára gömul lerkitré hafi orðið illa úti eða jafnvel drepist (3. mynd). Þar var raunar um að ræða tré sem stóðu höllum fæti fyrir sökum lerkiátu. Svipaða sögu er að segja úr Þjórsárdal og af ungu lerki í Mosfelli í Grímsnesi. Þar var áberandi nálafallssýki í fyrra og við úttekt á áburðartilraunum í Mosfelli haustið 2000 komu í ljós verulegar kalskemmdir á plöntum sem höfðu verið sýktar í fyrrasumar.

Tilraunir með varnarefni: Gerð var tilraun til að rjúfa smithring asp-arryðs með því að úða lerki skömmu eftir að það laufgaðist en lerki er sem kunnugt er millihýsill sveppsins (4. mynd). Tilraunin var gerð í Hveragerði og á Selfossi og var úðað í lok maí 2000. Notað var efnið Topas 100 EC, en það inniheldur 100 g/l penconasole. Lerkið var skoðað seinnipart júní og kom þá í ljós að úðunin hafði ekki borið tilætlaðan árangur.

Viðnám gegn greniryði: Könnuð var útbreiðsla greniryðs í kvæmatilraun með rauðgreni í Haukadal í Biskupstungum. Sumarið 1959 voru gróðursett þar ellefu kvæmi af rauðgreni frá mismunandi svæðum í Noregi, auk eins kvæmis frá Suður-Þýskalandi. Verulegur kvæmamunur reyndist vera á útbreiðslu ryðs í greninu, minnst ryð var í þýska kvæminu. Þessum rannsóknum verða gerð nánari skil síðar.

Viðnám gegn gljávíðiryði: Nú hefur verið safnað um 40 klónum af gljávíði, flestum úr klónasöfnum hjá Ólafi Sturlu Njálssyni í Nátthaga í Ölfusi og af Reykjavíkursvæðinu, auk nokkurra klóna frá Akureyri. Græðlingum var stungið í bakka vorið 2000 en ákveðið var að bíða með gróðursetningu þeirra til næsta vors. Græðlingarnir verða gróðursettir á Tumastöðum í Fljótshlíð og á Reykjavíkursvæðinu. Plönturnar verða smitaðar með gljávíðiryði nú í sumar og verður tilraunin tekin út nú í haust. Tæpast er þó að vænta áreiðanlegra niðurstaðna fyrr en að lokinni annarri úttekt sem verður haustið 2002.



4. mynd. Lífsferill asparryðsvepps á ösp og lerki. (Teikning Jón Guðmundsson).
Að sumrinu smitast öspin með skálagróum frá lerkinu og lifir sveppurinn í asparblöðunum og myndar ryðgró sem berast yfir á aðrar aspir og mynda þar ryðgró o.s.frv. allt sumarið. Þegar haustar myndast þelgró sveppsins, dvalagró sem lifa af veturinn í föllnu asparlaufinu. Um vorið fer fram blöndun erfðaefnis sveppsins er dvalagróin spíra og kólfgró sveppsins myndast og skila þau sveppnum upp úr sverðinum yfir á lerkinálar. Þar myndast síðan pyknogró í litlum blettum á nálunum en eftir að gagnstæðar æxlunargerðir sveppsins hafa náð saman þá myndast á lerkinálunum hópar skálagróa sem berast yfir á öspina og smita hana.

Viðnám gegn asparryði

Aðferðir: Rannsóknin var gerð í klónatilraun af alaskaösp á Böðmóðsstöðum í Laugardalshreppi (5. mynd). Sú tilraun er hluti af umfangsmiklum klónatilraunum með alaskaösp sem stofnað var til á árunum 1992-95 og eru niður-stöðum þeirra tilrauna gerð skil annars staðar í þessu riti. Aspar-plöntur af 40 mismunandi klónum voru gróðursettar í tilraunina á Böðmóðsstöðum sumarið 1995. Helmingur klónanna er upprunninn við strendur Alaska en hinir innar í landinu. Af þessum klónum eru raunar 9 klónar sem komnir eru af fræi sem safnað var af öspum hér á landi. Annarsvegar var um að ræða fræ sem safnað var af sjö trjám við Gilsbakkaveg og Oddagötu á Akureyri sumarið 1979. Hér eru þessir klónar taldir til innlandsklóna, enda eru móðurtrén talin vera upprunnin inni í landi. Hinsvegar er fræ sem talið er að hafi verið safnað af klóninum 'Laufeyju' sumarið 1983 og eru þeir klónar taldir til strand-klóna eins og móðirin. Tilrauninni er skipt í 10 blokkir, þ.e.a.s. hver tilraunaliður var endurtekinn 10 sinnum, og eru 4 plöntur af hverjum klón í hverri blokk, Fyrst var reynt að smita öspina þann 23. júní, þannig að smitaðar lerkigreinar voru hristar yfir aspirnar. Hér var því í raun verið að dreifa skálagróum sveppsins yfir á öspina líkt og gerist við náttúrlegar aðstæður (sbr. 4. mynd). Þegar til-raunin var skoðuð á ný fyrrihluta ágústmánaðar kom í ljós að þessi smittilraun hafði ekki tekist sem skyldi. Því var reynt að smita öspina með ryðgróum frá smituðum öspum. Smituðum asparblöðum var safnað þann 17. ágúst á Selfossi og þau hrist yfir aspirnar í klónatilrauninni. Sú smitun tókst allvel. Smitaðar voru sex blokkir af tíu, þ.e.a.s. blokk 1, 2, 5, 6, 9 og 10. Af hverjum klón voru því allt að 24 plöntur með í tilrauninni.

Í reynd voru þær þó gjarnan

5. mynd. Klónatilraunin á Böðmóðs-stöðum, yfirlitsmynd. Mynd: H.S.

nokkru færri. Þetta orsakaðist af því að plöntur höfðu drepist eða voru svo lélegar að þeim var sleppt. Einn klónn skar sig úr hvað slík afföll snerti. Af honum voru aðeins 4 plöntur lifandi í tilraunablokkunum og var honum því sleppt. Þá voru tveir klónanna aðeins í hluta tilraunarinnar og var þeim einnig sleppt úr tilrauninni. Í smitunar-tilrauninni voru því samtals 37 klónar, 19 innlandsklónar og 18 strandklónar.

Tilraunin var tekin út þann 19. september. Þá var smit á öllum tilraunatrjánum ákvarðað. Mat á smiti var gert í tveimur áföngum Fyrst var útbreiðsla smits í hverju tré metið. Gefnar voru fjórar ein-kunnir fyrir útbreiðslu smits í tré:

1. Ekkert smit fannst.
2. Smit í toppi.
3. Smit víða í tré.
4. Smit útbreitt um allt tréð.

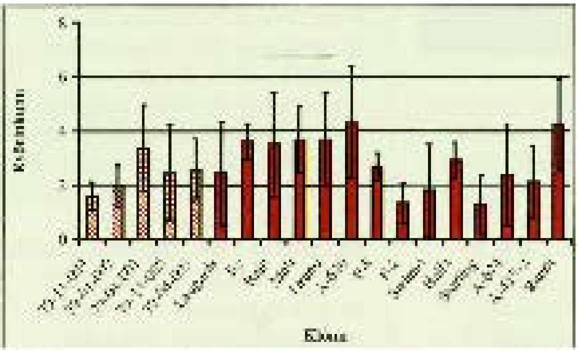
Ef smit fannst í trénu var útbreiðsla þess á blöðum asparinnar metin, þannig að meðalfjöldi ryðbletta á smituðum blöðum var áætlaður. Gefnar voru þrjár einkunnir fyrir meðalfjölda ryðbletta á smituðum blöðum:

1. Færri en 5 ryðblettir.
2. 5-20 ryðblettir.
3. Yfir 20 ryðblettir.

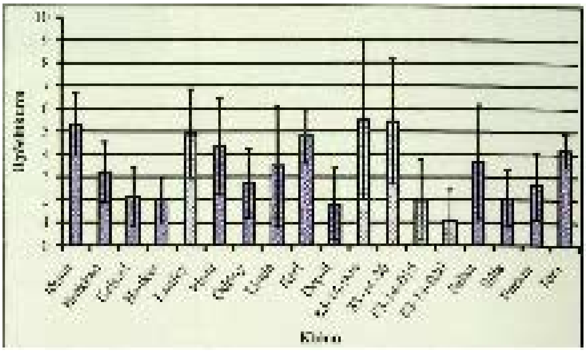
Út frá þessum einkunnum var síðan reiknuð ryðeinkunn. Það var gert með því að margfalda saman einkunn fyrir útbreiðslu smits í tré og einkunn fyrir útbreiðslu smits á blöðum. Plöntur með háa ryðeinkunn voru því með mikið og útbreitt ryð.

Niðurstöður og umræður:
Útbreiðsla smits var mjög mis-munandi eftir klónum (6. og 7. mynd). Á innlandsklónum var minnst ryð á klónunum 'P-2' og 'Sterling' (ryðeinkunn 1,3) en mest á 'A-640' og 'Randa' (ryðeinkunn 4,2-4,3). Öllu meiri munur var á ryði á strandklónum. Þar var minnst ryð á klónunum '83-14- 020' og 'Depli' (ryðeinkunn 1,1 og 1,8) en mest á 'Iðunni', '83-14-004' og '83-14-36' (ryðeinkunn 5,3-5,5). Af vel þekktum klónum má benda á að 'Iðunn', 'Laufey' og 'Pinni' fá allir slæma einkunn (ryðeinkunn 4,3-5,3), en 'Keisari' og 'Haukur' fá allgóða einkunn (ryðeinkunn 2- 2,1). 'Sælandsösp' er raunar með enn lægri ryðeinkunn (1,8), en menn þóttust einmitt hafa tekið eftir því í Hveragerði í fyrra að sá klónn hefði komist áberandi vel frá ryðfaraldrinum. Þá er rétt að vekja athygli á því að einkunn klónanna 'Sölku' og 'Jóru' er mjög svipuð, en erfðafræðirannsóknir benda eindregið til þess að þetta sé í raun einn og sami klónninn.
Í þessari grein verður ekki rakið hvar má finna marktækan mun á ryðeinkunn einstakra klóna en milli lökustu klónanna og þeirra bestu er alls staðar marktækur munur. Þeir klónar sem á milli liggja eru hinsvegar hvorki marktækt frábrugðnir bestu né lökustu klónunum.

Í fljótu bragði virðist vera meiri munur á ryði milli strandklóna en milli innlandsklóna. Það kemur ekki á óvart og kemur heim og saman við niðurstöður annarra rannsókna á alaskaasparklónum hér á landi. Þetta stafar væntanlega af því að öspin vex einkum við árbakka í Alaska og sprotar eða tré sem áin hrífur með sér í vatnavöxtum skjóta gjarnan rótum á eyrum neðar við ána.
Þannig berst nýtt erfðaefni mun greiðar niður til strandar en í gagnstæða átt. Það vekur athygli í þessu sambandi að breytileiki í ryðeinkunn klónanna sem komnir eru af akureyrsku fræplöntunum er mun minni en breytileiki í ryð-einkunn klónanna sem komnir eru af 'Laufeyju' (6. og 7. mynd, skáletraðar súlur). Það er raunar áberandi að tveir af afkomendum 'Laufeyjar'; 83-14-004 og 83-14-36 eru með mjög svipaða ryðeinkunn og móðirin, öll í hópi verstu klóna. Hinir tveir; 83-14-015 og 83-14-020, eru í hópi bestu klóna og sá síðarnefndi er raunar sá klónn sem fékk lægsta ryðeinkunn. Þetta bendir eindregið til þess að auðvelt sé með kynbótum að rækta klóna sem séu lítt ryðsæknir. Vandamálið við slíkar kynbætur sem og kyn-bætur yfirleitt er að oft vill fylgja böggull skammrifi, þ.e.a.s. góðum eiginleika fylgir oft annar miður æski-



6. mynd. Ryð á 19 innlandsklónum af ösp. Skástrikaðar súlur eru aspir sem eiga ættir að rekja til plantna sem voru aldar upp af fræi sem safnað var við Gilsbakkaveg og Oddagötu á Akureyri sumarið 1979. Lóðréttar línur sýna staðalfrávik.

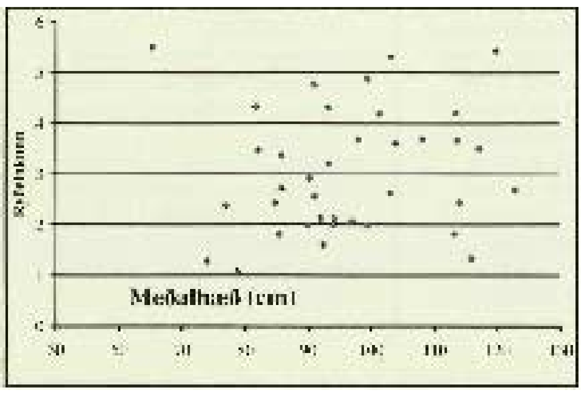


7. mynd. Ryð á 18 strandklónum af ösp. Skástrikaðar súlur eru aspir af klóninum 'Laufey' og fjórum klónum sem komnir eru af fræi af 'Laufey' sem safnað var sumarið 1983. Lóðréttar línur sýna staðalfrávik.

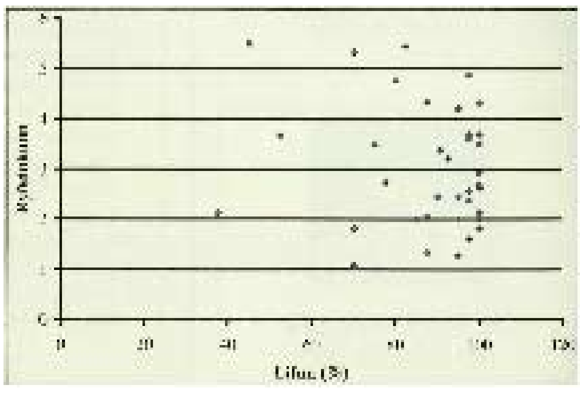
legur. Þannig er til að aspir sem hafa mikinn vaxtarþrótt geti haft lélegan viðnámsþrótt gegn skaðvöldum. Þetta orsakast væntanlega af því að orka trésins sé fyrst og fremst nýtt til vaxtar á kostnað varnarefnaframleiðslu. Einnig er velþekkt að tré sem þrífast illa eigi erfitt með að verjast sjúkdómum. Því var kannað hvort ryðeinkunn klóna væri háð vaxtargetu og lífsþrótti þeirra. Þetta var gert með því að bera hæð og lifun klóna haustið 1999 saman við ryðeinkunn þeirra haustið 2000. Ekki virtist vera neitt samband á milli ryðeinkunnar og hæðar klóna (8. mynd) né milli ryðeinkunnar og lifunar klóna (9. mynd). Þannig er það ýmist að klónar sem eru lítið ryðsæknir vaxi vel eða illa og lifi vel eða illa. Til dæmis var 'Sælandsösp' með lága ryðeinkunn og er yfir meðallagi hvað lifun og vöxt áhrærir. Hinsvegar var sá klónn sem var með lægsta ryðeinkunn, þ.e.a.s. 83-14-020, undir meðallagi í vexti og lifun.

Ekki er hægt að segja annað en að þessar frumniðurstöður lofi góðu. Í því klónasafni af alaskaösp sem þegar er í tilraunum hér á landi virðist vera mikill breytileiki hvað mótstöðuþrótt gegn asparryði áhrærir. Enginn klónn virðist þó vera fullkomlega ónæmur fyrir þessum sjúkdómi, enda er það ekki eins æskilegt og ætla mætti í fljótu bragði. Kynbætur á ösp í Evrópu, þar sem asparryð er verulegt vandamál, snúast að verulegu leyti um að finna klóna sem hafi nægan viðnámsþrótt gegn þessum sjúkdómi. Í fyrstu beindust kynbætur að því að finna klóna sem væru algjörlega ómóttækilegir fyrir ryði, en sú aðferð gafst illa þar eð fljótlega komu fram nýir stofnar sveppsins sem þessar kyn bættu aspir stóðu berskjaldaðar gegn. Í seinni tíð hafa menn því einbeitt sér að því að finna asparklóna sem hafi mikinn mótstöðuþrótt, en eru ekki fullkomlega ónæmir. Þær frumniðurstöður sem hér liggja fyrir benda til þess að hérlendis sé úr töluverðum

8. mynd. Samband milli meðalhæðar klóna, mælt haustið 1999, og útbreiðslu ryðs haustið 2000.



9. mynd. Samband milli lifunar klóna, mælt haustið 1999, og útbreiðslu ryðs haustið 2000..



slíkum efniviði að moða. Það einfaldar mjög allt val úr þeim efniviði að tilraunir með asparklóna hafa staðið í nokkur ár og hafa nú þegar safnast miklar upplýsingar um aðra eiginleika þessara klóna.
Tölfræðilegt yfirlit: Fervikagreiningu var beitt við úrvinnslu mælinga. Heildar niðurstöður sýndu að marktækt samband var á milli klóna og ryðeinkunnar (F = 1,732, P = 0,008) og blokka og ryðeinkunnar (F = 8,44, P (0,001). Marktækt samband milli blokka og ryðeinkunnar stafaði af því að ryð var mun minna í blokk níu og tíu heldur en í hinum blokkunum, enda voru þær blokkir smitaðar seinast og var heldur lítið eftir af vel smituðum asparblöðum þegar kom að því að smita þær. Blokkum níu og tíu var því sleppt í tölfræðiuppgjöri. Þegar það hafði verið gert var enn marktækt samspil milli klóna og ryðeinkunnar (F = 2,236, P = 0,001) en ekki milli blokka og ryðeinkunnar (F = 0,573, P = 0,633).

Þakkir
Þær rannsóknir á mótstöðuþrótti aspar gegn asparryði sem hér hefur verið greint frá eru styrktar af Skógarsjóðnum, Framleiðnisjóði landbúnaðarins og RANNÍS. Þá hafa Landshlutabundin skógræktarverkefni og sveitarstjórnir í Hveragerði og Árborg lagt fram styrk til rannsókna á trjásjúkdómum. Þessum aðilum vilja höfundar færa bestu þakkir fyrir þeirra framlag.

SUMMARY

Poplar leaf rust *(Melampsora larici-populina* Kleb.) was recorded for the first time in Iceland in 1999. The resistance of 37 different clones of black cottonwood *(Populus trichocarpa* Torr. & Grey) to poplar leaf rust was assessed in a clonal trial in South Iceland during the summer of 2000. This clonal trial was established in 1995 and is arranged in 10 blocks containing 40 randomly arranged clones. Three clones were however left out of the present study as they were only partially represented in the trial. Larch branches infected with the fungi, were collected in June 23rd and aecidospores of the fungi dusted over the black cottonwood trees. Inspection in early August showed that this infection had been unsuccessful. A second attempt was made on August 17th, this time using rust infected black cottonwood leaves. This infection proved to be successful.

The trial was assessed on September 19th. The distribution of rust on each tree was scored, as well as number of rust spots on infected leaves. The total score was found by multiplying these two scores. Statistical analysis showed a highly significant relationship between clones and total rust score (F = 2,236, P = 0,001). This trial shows that clones of black cottonwood, already present in Iceland, have a significant potential in breeding/selecting plant material resistant to this disease.

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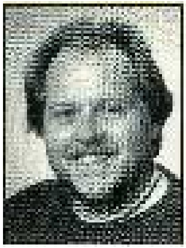


Þröstur Eysteinsson

Herdís Friðriksdóttir

Lárus Heiðarsson

Vöxtur fjögurra grenitegunda og lerkis í tilraun frá 1965

Inngangur

Á undanförnum árum hafa hugmyndir íslensks skógræktarfólks um hvernig best sé að rækta skóg tekið breytingum. Meðal þeirra hugmynda sem nú eru áberandi í skógræktarumræðunni eru að það borgi sig tvímælalaust að gera vel við plönturnar á fyrstu árum eftir gróðursetningu og að gott geti verið að blanda saman tegundum (Sjá t.d. Björn Jónsson 1998, Landbúnaðarráðuneytið 1999).

Ekki er lengur talið ásættanlegt að bíða í 10-20 ár frá gróðursetningu þar til plönturnar hefja vöxt, enda engin ástæða til. Það er ekki náttúrulögmál að trjáplöntur vaxi hægt í upphafi, þvert á móti eru flestar trjátegundir sem notaðar eru í skógrækt hér á landi þannig gerðar að þær hafa mestan vaxtarþrótt á unga aldri (fyrstu 20-40 árin) ef umhverfisaðstæður leyfa. Tré sem staðnar í vexti í 20 ár vegna næringarskorts eða samkeppni frá grasi missir af stórum hluta af sinni vaxtargetu því lífeðlisfræðileg öldrun á sér engu að síður stað (Greenwood o.fl. 1989).

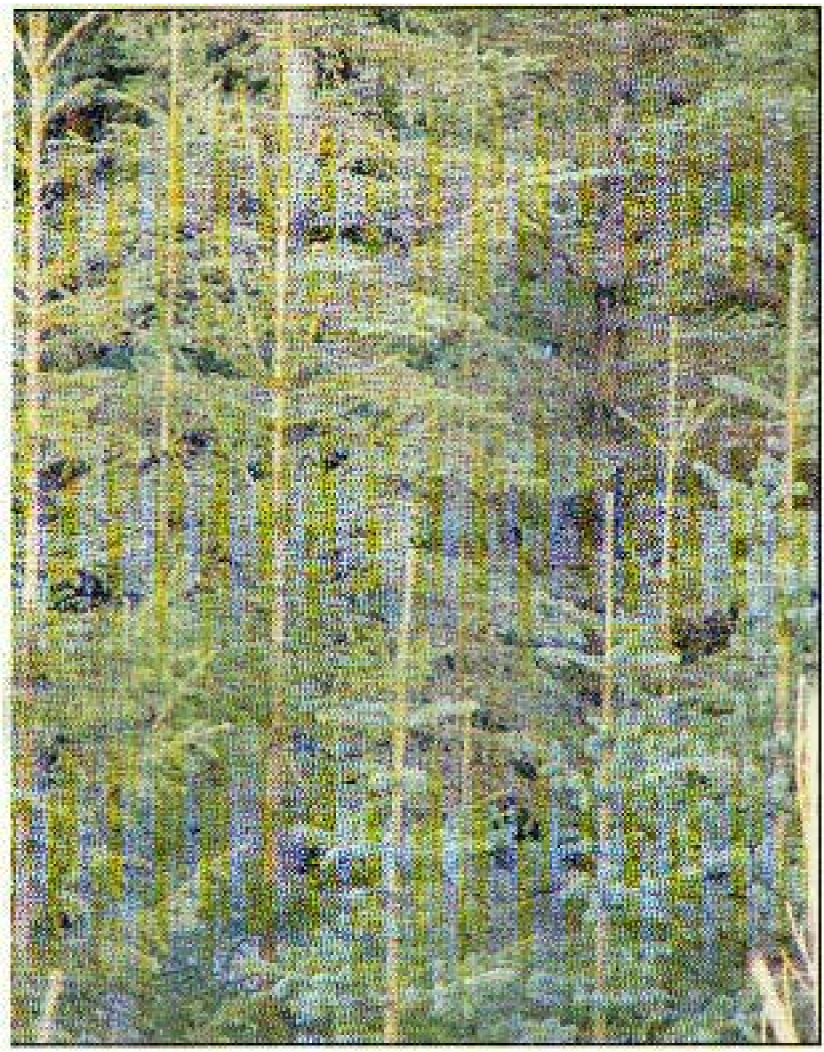
Val á vel aðlöguðum tegundum, kvæmum og klónum og kynbætur geta fært okkur efnivið sem þolir íslenska veðráttu. Sú aðlögun dugar þó skammt ef plönturnar skortir næringarefni, vatn eða birtu vegna rýrs jarðvegs eða samkeppni við annan gróður. Lausnir á þessum vanda eru tæknilega mjög einfaldar en vinnukrefjandi, og þær eru að undirbúa gróðursetningu með einhverskonar jarðvinnslu, bera áburð á plönturnar við gróðursetningu og hirða um plönturnar eftir gróðursetningu, t.d. með endurtekinni áburðargjöf og með því að reyta frá. Þegar trén eru orðin aðeins stærri getur það einnig bætt vöxt þeirra að hafa góða granna, t.d. tré annarrar tegundar sem veita skjól eða bæta jarðvegsskilyrði.

Nýverið hafa Jón Guðmundsson (1995) og Hreinn Óskarsson o.fl. (1997) gert tilraunir með áburðargjöf á nýgróðursettar trjáplöntur, en þetta eru þó ekki fyrstu rannsóknir á því sviði hérlendis. Árið 1965 settu þeir Sigurður Blöndal, skógarvörður, og Jón Jósep Jóhannesson út áburðar- og 'jarðvinnslu' tilraun að Mjóanesi á Fljótsdalshéraði. Frá þessari tilraun greinir Sigurður Blöndal í pistli sínum „Fyrr og nú“ í Skógræktarritinu 1995 og kallar „Fálmað með greni“. Þótt tilraunin hafi ekki verið sett út samkvæmt kúnstarinnar reglum tölfræðinnar má draga heilmikinn lærdóm af henni, ekki síst af því að hún er orðin 35 ára gömul.

Fyrir utan samanburð á áburðarmeðferðum og túlkun á umhverfisþáttum er fróðlegt að bera saman grenitegundirnar fjórar sem þarna voru gróðursettar m.t.t. vaxtar við þær aðstæður sem þarna ríkja. Þess má geta að eitt stærsta skógræktarverkefni landsins, Héraðsskógar, stendur fyrir ræktun á sömu slóðum og að mestu á svipuðu landi.

Efni og aðferðir

Tilraunin var gróðursett í ágúst 1965 skammt fyrir neðan þjóðveg utarlega í landi Mjóaness í Vallahreppi, en Skógrækt ríkisins hafði þá nýlega fengið landið til umsjónar. Svæðið er í vægri brekku sem hallar til norðvesturs niður að Lagarfljóti. Gróður á svæðinu



1. mynd. Blágreni er fallegt en það stenst hinum tegundunum ekki snúning í vexti. Mynd: Þ.E. 2000.

var þursaskeggsmói, sem er mjög rýrt þurrlendi og einkum talið henta lerki en alls ekki greni.

Notaðar voru 4 grenitegundir: Sitkagreni (*Picea sitchensis* (Bong.) Carr) frá Homer í Alaska, blágreni (P. *engelmannii* (Parry) Engelm.) frá Sapinero í Colorado (1. mynd), hvítgreni (P. *glauca* (Moench) Voss) frá Summit Lake í Alaska og rauðgreni (P. *abies* (L.) Karst.) kvæmi óvisst en þrír staðir á svipuðum slóðum í N-Noregi koma til greina. Til hliðar við grenitilraunina voru tvö rússalerkikvæmi *(Larix sukaczewii* Dylis) gróðursett, Raivola og Arkhangelsk. Plönturnar voru berrótarplöntur frá gróðrarstöðinni á Hallormsstað á aldrinum 2/2 (lerkið), 2/3 (blágrenið og rauðgrenið), 3/3 (hvítgrenið) og 2/5 (sitkagrenið).

Grenið var gróðursett í fjórar blokkir og var bjúgskófla notuð við gróðursetningu. Innan hverrar blokkar voru fjórar 25-trjáa raðir, þ.e. ein röð með hverri grenitegund, gróðursettar upp eftir brekkunni. Gróðursett var með eins metra millibili eða sem samsvarar 10.000 tré á ha og reiturinn hefur aldrei verið grisjaður Blokkirnar liggja samhliða þvert á brekkuna, blokk I syðst og blokk IV nyrst.

Hver blokk fékk sína áburðarmeðferð: Plönturnar í blokk I fengu allar 10 g af garðáburði (NP:K 14:18:18), í blokk II fengu plönturnar einn hnefa af húsdýraáburði og þar var bjúgskófluhnausinn mulinn (jarðvinnsla), blokk III var viðmiðunin og fengu plönturnar þar hvorki áburð né jarðvinnslu og í blokk IV fengu plönturnar 10 g af garðáburði og hnefa af skít og þar var hnausinn einnig mulinn. Tvær 25-trjáa raðir af lerki voru gróðursettar sunnan við syðstu röð í blokk I; kvæmið Arkhangelsk næst greninu og fékk hver planta 10 g af garðáburði og þar fyrir sunnan kvæmið Raivola en þar fékk hver planta hnefa af mold úr græðireit í gróðrarstöð. Lerkið var gróðursett með eins metra bili innan raða en 1,5 m milli raða. Fyrir sunnan Raivola lerkið var gróðursett broddfura sem óx mun hægar, þannig að Raivola lerkið myndar í raun skógarjaðar (Sigurður Blöndal 1995 úr dagbók Jóns Jóseps Jóhannessonar). Í grein Sigurðar frá 1995 er að finna uppdrátt af tilraunarskipulaginu úr dagbók Jóns Jóseps.

Árið 1966 var svo lerki gróðursett fyrir neðan tilraunina og norðan við hana þannig að grenið varð umkringt lerki á þrjá kanta. Árið 1985 var svo lerki gróðursett ofan við tilraunina.

Sumarið 1997 mældi Herdís Friðriksdóttir grenitilraunina auk lerkiraðanna tveggja sunnan við hana. Mæld voru hæð og þvermál í brjósthæð á hverju tré. Auk þess var lifun skráð. Viðarmagn var reiknað út frá eftirfarandi líkönum:

Fyrir sitkagreni og blágreni (Gunnar Freysteinsson 1996 eftir Bauger 1995):

$$0{,}1614 \times H^{3{,}706} \times ÞBH^{1{,}947} \times (H-1{,}3)^{-2{,}2905} \times (ÞBH + 40)^{-0{,}6665}$$

Fyrir hvítgreni og rauðgreni (Arnór Snorrason og Þór Þorfinnsson 1995):

$$-0{,}771711 + 0{,}027176 \times ÞBH^2 \times H + 0{,}155777 \times ÞBH \times H$$

Fyrir lerki (Gunnar Freysteinsson 1996 eftir Norrby 1990):

$$e^{-2{,}5079} \times ÞBH^{1{,}7574} \times H^{0{,}9808}$$

Þar sem H er hæð, ÞBH er þvermál í brjósthæð (1,3 m frá jörðu) og e = 2,71828.

Viðarmagn á ha og árlegur viðarvöxtur var síðan reiknaður út frá þéttleika reitsins í heild eins og hann er nú, þ.e. 7300 tré á ha fyrir grenið og 5600 tré á ha fyrir lerkið, og aldri frá gróðursetningu, sem var 32 ár þegar mælingar fóru fram. Uppsetning tilraunarinnar leyfir ekki formlegan tölfræðilegan samanburð þar sem dreifing meðferða og tegunda var ekki tilviljunarkennd. Einnig gerir uppsetningin og umgjörð tilraunarinnar túlkun á niðurstöðum erfiða, t.d. vegna munar á skilyrðum innan blokka efst og neðst í brekku og vegna mismikillar nálægðar bæði tegunda og blokka við lerki. Til dæmis vaxa 28 % trjáa í blokkum I og IV við hlið lerkis en aðeins 4 % í blokkum II og III. Eins vaxa 28% sitkagrenis og rauðgrenis við hlið lerkis en aðeins 4 % blágrenis og hvítgrenis. Þetta þýðir að allar niðurstöður verður að taka með fyrirvara þar sem þær eru ekki studdar jafnsterkum rökum og ef hægt hefði verið að beita tölfræðilegum samanburði. Þá ber að hafa í huga að samanburður milli tegunda er í raun samanburður milli tiltekinna kvæma þessara tegunda.

Niðurstöður

Eftir meðferð við gróðursetningu

Lifun í blokkum I og IV, þar sem plöntur fengu tilbúinn áburð, var um 20% minni en í blokkum II og III þar sem ekki var gefinn tilbúinn áburður (2.mynd). Þá lifir 92% af Raivola-lerkinu, sem ekki fékk áburð, en aðeins 76% af Arkhangelsklerkinu, sem fékk tilbúinn áburð,

Hjá öllum tegundum er viðarvöxtur lakastur í blokk III, þar sem trén fengu engan áburð við gróðursetningu (3. mynd). Munur á viðarvexti á blokk III og bestu meðferð er frá því að vera rúmlega 1/3 hjá hvítgreni og upp í að vera fimmfaldur hjá rauðgreni. Minni munur er á bestu og verstu meðferð þegar hæðarvöxtur er skoðaður eða frá 18% hjá hvítgreni til 64% hjá rauðgreni.

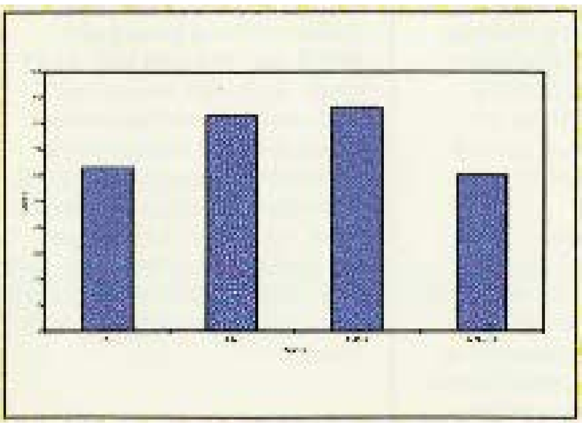
Eftir tegund

Lifun var áberandi lökust hjá blágreni, eða aðeins 48% borið saman við 75-86% hjá hinum grenitegundunum og var þessi munur svipaður í blokkunum þremur sem fengu áburðarmeðferð en minni í viðmiðunarblokkinni.

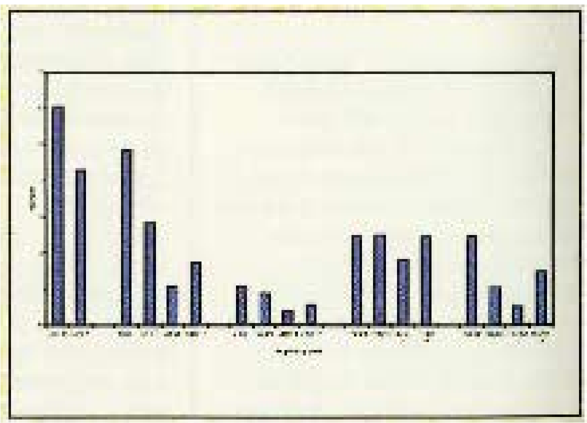
Meðaltalstölur yfir hæð, þvermál í brjósthæð (þ.b.h.), viðarmagn og árlegan viðarvöxt sýna allar sömu niðurstöðu. Vöxtur blágrenis var lakastur. Þó var vöxtur rauðgrenis ekki teljandi betri en vöxtur blágrenis í tveimur blokkum af fjórum. Besti vöxtur blágrenis (blokk I) var á við lakasta vöxt sitkagrenis (blokk III) (3. mynd). Vöxtur sitkagrenis var bestur, en einkum vegna blokkar I. Í hinum blokkunum var ekki áberandi munur á sitkagreni, rauðgreni og hvítgreni.

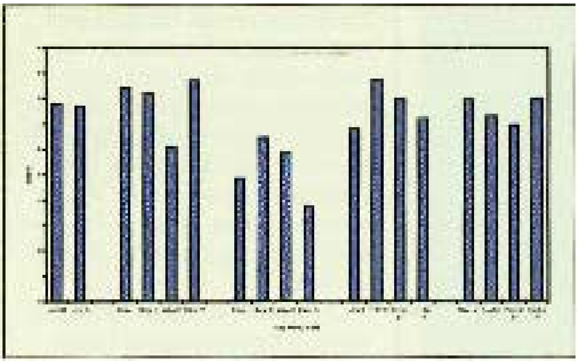
Yfirhæð, í þessu tilviki hæð hæsta trésins, er mjög svipuð hjá sitkagreni, hvítgreni og rauðgreni og eru hæstu tré þessara tegunda orðin hærri en hæsta lerkið (4. mynd). Hæsta blágrenið er

2. mynd. Lifun eftir meðferð við gróðursetningu.



3. mynd. Meðal árlegur viðarvöxtur í m/ha/ár.





4. mynd. Hæð hæstu trjáa í hverri röð.

komið upp fyrir 6 m en er þó fullum tveim metrum lægra en hæstu sitka- og hvítgrenitrén.

Þvermálsvöxtur og þar af leiðandi viðarvöxtur Raivolalerkisins var meiri en hjá Arkhangelsklerkinu og greninu. Stafar það af því að sú röð myndaði jaðar og hafa trén því stærri krónur en hin.

Eftir öðrum umhverfisþáttum

Syðsta sitkagreniröðin (blokk I) óx áberandi betur en aðrar raðir í tilrauninni og er nærtækasta skýringin nálægð við lerkiraðirnar tvær. Nyrsta rauðgreniröðin (blokk IV) vex reyndar einnig við hlið lerkis en sýndi ekki sama vaxtarauka.

Þótt ekki væri nema um 5 m munur á hæð lands efst og neðst í tilrauninni var vaxtaraukning mikil þegar neðar dró í brekkunni. Meðalhæð trjáa í tveimur neðstu röðunum þvert á blokkirnar fjórar var nálægt þrefaldri meðalhæð trjánna í tveimur efstu röðum (5. mynd).

Umræða og ályktanir

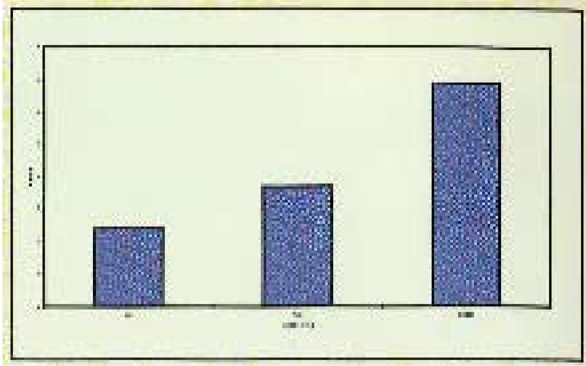
Meðferð við gróðursetningu

Vegna uppsetningar tilraunarinnar og truflandi umhverfisþátta er fátt hægt að álykta um áhrif mismunandi meðferða við gróðursetningu. Munurinn á lifun milli trjáa sem fengu tilbúinn áburð og þeirra sem fengu hann ekki var umtalsverður. Hins vegar verður að teljast ósennilegt að áburðurinn hafi valdið auknum afföllum beint þar sem áburðarmagnið var lítið eða aðeins 1,4 g af hreinu köfnunarefni á plöntu (sjá Hreinn Óskarsson o.fl. 1997). Stóran hluta affallanna í blokkunum sem fengu tilbúinn áburð má skýra með miklum afföllum blágrenis. Hugsanleg skýring er að öflugur grastoppur hafi myndast við plönturnar sem fengu tilbúinn áburð og að blágrenið hafi annað hvort 'kafnað' í grasi eða að grasið hafi virkað sem einangrun frá útgeislun jarðar á frostnóttum og leitt til aukinna frostskemmda.

Hvað varðar vöxt er hvorki hægt að greina á milli áhrifa húsdýraáburðar og tilbúins áburðar né milli þess að mylja bjúgskófluhnausinn eða hafa hann heilan. Þetta stafar af því að ekki er hægt að beita tölfræði við samanburð og af truflandi umhverfisáhrifum en ekki af því að það sé enginn munur. Hins vegar er nokkuð ljóst að allar áburðar- og jarðvinnslumeðferðir leiða til betri vaxtar en að gera ekkert og sá munur getur verið mjög mikill og er enn sjáanlegur eftir 32 ár.

Tegundir

Blágrenið var áberandi lakast hvað varðar lifun og vöxt. Kvæmið sem notað var, Sapinero, er úr mjög svipaðri hæð og önnur kvæmi frá Colorado sem notuð hafa verið hér, s.s. Rio Grande.



5. mynd. Meðalhæð í tveimur efstu röðum, tveimur röðum í miðjum reit og tveimur neðstu röðum í brekkunni þvert á allar grenitegundir.

Reynsla í gróðrarstöðvum er sú að blágreni frá Colorado er viðkvæmt fyrir haustfrostum á unga aldri ekki síður en sitkagreni á meðan bæði hvítgreni- og rauðgrenikvæmin sem við notum eru harðgerari. Þetta dregur hvorki úr notagildi blágrenis sem garðtrés né í jólatrjáarækt en hinar tegundirnar eru betri kostir til timburskógræktar í innsveitum norðan- og austanlands.

Sitkagreni kom best út, einkum vegna raðarinnar sem vex við hlið lerkisins. Hugsanlega hefur það einnig hjálpað til í sambandi við lifun að sitkagreniplönturnar voru 7 ára gamlar við gróðursetningu eða tveimur árum eldri en blágrenið. Út frá þessari tilraun er þó ekki hægt að álykta að sitkagreni vaxi að jafnaði betur en hvítgreni eða rauðgreni í innsveitum norðan- og austanlands. Það á því ekki að útiloka neina þeirra í skógrækt á þessum slóðum

Undanfarin ár hefur mun meira verið gróðursett af lerki og stafafuru í timburskógrækt en af sitkagreni eða sitkabastarði, lítið hefur verið gróðursett af hvítgreni og nánast ekkert af rauðgreni. Þó er ljóst að hlutfall beinvaxinna trjáa er mun lægra hjá lerki og furu en hjá grenitegundunum, sérstaklega miðað við hvítgreni og rauð-

6. mynd. Góðir grannar. Rússalerki og hvítgreni í góðum vexti. Mynd: Þ.E. 2000.

greni. Í því skyni að auka fjölbreytni og öryggi í nytjaskógrækt ætti tvímælalaust að auka hlut grenis, sérstaklega hvítgrenis og rauðgrenis við nýskógrækt.

Þessar þrjár grenitegundir bjóða upp á val vegna mismunandi aðlögunar. Sitkagreni hefur mikla vaxtargetu og er vindþolið en er viðkvæmt fyrir haustfrostum. Þess vegna á að velja því stað í brekkum og stöðum þar sem vindasamt er. Rauðgreni er ekki nærri eins vindþolið en er frostþolið eins og hvítgreni. Væri því rétt að velja þessar tegundir við gróðursetningu á flatlendi, rauðgreni þar sem sæmilegt skjól er en hvítgreni þar sem er næðingssamara. Þar sem þessar tegundir eru allar skuggþolnar á unga aldri má blanda þeim saman við lerki, furu, birki eða ösp og ætti það að koma betur út en að blanda ljóselskum tegundum saman, t.d. lerki og furu. Svo eru þessar grenitegundir misviðkvæmar fyrir hinum ýmsu sjúkdómum og skordýraplágum og því æskilegt að nota þær allar til að draga úr áhættu þeirri sem fylgir því að notast við fáar tegundir.

Önnur umhverfisáhrif

Líklegt er að munur sé á jarðraka efst og neðst í tilrauninni. Landið neðst í tilrauninni og fyrir neðan hana er flatt og því sennilega betri rakaskilyrði en ofar í brekkunni.

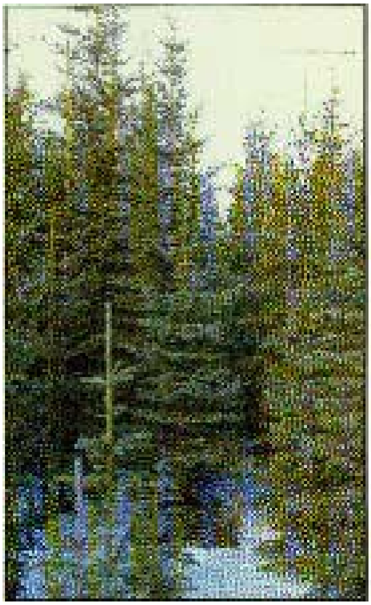
Hæstu trén eru neðarlega og er greinilegt að grenið nýtur mjög góðs af auknum raka eða nálægð við lerki sem þar er einnig nema hvort tveggja sé. Undantekning er syðsta sitkagreniröðin, sem vex öll við hlið lerkis, en þar er ekki munur á hæð niður eftir brekkunni. Nyrsta rauðgreniröðin vex einnig við hlið lerkis en sýnir ekki sama vaxtarauka skv. mælingum. Þeim megin er lerkið bæði gisnara og lágvaxnara en sunnan og neðan við tilraunina. Vöxtur rauðgrenisins í nyrstu röð hefur reyndar verið mjög mikill þau 4 ár síðan tilraunin var mæld og er hugsanlegt að áhrif lerkisins séu að koma fram seinna þar.

Lerkið í tilrauninni sýnir ekki vaxtarauka niður eftir brekkunni. Þetta gæti þýtt að jarðraki efst í brekkunni sé ekki takmarkandi fyrir vöxt þess á sama hátt og hann virðist vera fyrir grenið. Þetta gæti einnig verið vísbending um að það sé ekki afgerandi munur á jarðraka efst og neðst í tilrauninni og að aukinn vöxtur grenis syðst og neðst í henni skýrist fyrst og fremst af nálægð við lerki.

Lerki hefur ótrúlega hæfileika til að nema næringu úr rýrum jarðvegi og er það hugsanlega vegna samspils sveppróta lerkisins og köfnunarefnisbindandi jarðvegsörvera. Aðrar tegundir, s.s. stafafura, virðast einnig hafa þessa hæfileika þótt þær séu ekki eins öflugar. Rótarkerfi lerkisins virkar þá sem áburðarverksmiðja og öruggt má telja að nærliggjandi tré njóti góðs af þessum hæfileikum lerkisins (6. mynd). Gróðursetning lerkis var því fjórða áburðarmeðferðin á grenið í þessari tilraun og sú sem gaf mestan vöxt til langs tíma eftir því sem best verður séð. Áhrif lerkisins koma þó ekki grönnum þess til góða fyrr en rótarkerfi trjánna ná saman. Slíkur samvöxtur rótarkerfanna tekur alltaf nokkur ár frá gróðursetningu þannig að blöndun lerkis með greni kemur ekki í staðinn fyrir áburðargjöf við gróðursetningu.

Lokaorð

Myndirnar sem fylgja þessari grein voru teknar í október 2000. Grenið er í mjög miklum vexti og hafa drottnandi tré hækkað um allt að 2 metra þau 4 ár síðan mælingarnar sem hér eru birtar voru gerðar (7. mynd). Vegna þéttleika hafa lægri tré, þ.á.m. blágrenið, dregist enn frekar afturúr. Ennfremur hefur lerki gróðursett 1985 fyrir ofan tilraunina náð góðri stærð og er grenilundurinn því umkringdur lerki nú. Áhrif lerkisins ná nú sennilega að einhverju leyti um reitinn allan.



7. mynd. Yfirlit yfir grenitilraunina í október 2000. Eins og sést hefur vöxtur verið mikill síðan trén voru mæld 1997.

Helsti lærdómur sem draga má af niðurstöðunum nú er 1) að sitkagreni, hvítgreni og rauðgreni eru allt gjaldgengar tegundir í nytjaskógrækt í innsveitum norðan- og austanlands og 2) að vel er hægt að rækta greni á rýru landi ef notuð er tilheyrandi jarðvinnsla og áburðargjöf og sérstaklega ef grenið er gróðursett í bland með lerki.

Það verður gaman að fylgjast áfram með þessum grenireit og enn verður hægt að draga lærdóm af þessu 'fálmi með greni'.

Þakkarorð

Þeim Sigurði Blöndal, Hreini Óskarssyni og Sherry Curl er þakkað fyrir yfirlestur á drögum að grein þessari.

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JÓN ÍSBERG

Gunnfríðarstaðaskógur á Bakásum

Í grein um Gunnfríðarstaði eða öllu heldur um Gunnfríðarstaðaskóg, sem fyrrverandi skógræktarstjóri, Sigurður Blöndal, ritar í 2. tbl. Skógræktarritsins 2000, segir hann „söguna á bak við söguna“ um tildrög og upphaf skógræktar að Gunnfríðarstöðum. Heimildarmann segir hann vera Gísla bónda Pálsson á Hofi í Vatnsdal. Allmikillar ónákvæmni gætir í frásögn þeirra svo ekki sé meira sagt enda liðlega 40 ár frá upphafi þeirra atburða, sem frá er greint og báðir orðnir nokkuð aldraðir og ég er það raunar líka, en sá munur er á, að ég hefi fyrir framan mig fundargerðir frá þessum tíma en þeir ekki. Það er ekki góð sagnfræði að ætla sér eingöngu að treysta á minnið.

Haldinn var stjórnarfundur í skógræktarfélaginu 30. jan. 1958. Þar mæta bara tveir stjórnarmanna, formaðurinn Páll Jónsson, skólastjóri á Skagaströnd og ritari félagsins Ágúst Jónsson, bóndi og skógræktarmaður á Hofi. Jón S. Pálmason, Þingeyrum, „var eigi mættur“. Þótt ekki séu fleiri mættir, er fundargjörðin upp á þrjár blaðsíður í fjórðungsbroti. Nokkur mál eru tekin fyrir og þeir hvetja til aukinnar skógræktar.

Næsti fundur er aðalfundur haldinn sunnudaginn 15. maí 1960. Formaður ávarpaði fundarmenn og gat þess, að við erfiðleika hafi verið að stríða í starfsemi félagsins, en undanfarið hafi verkefni þess einkum verið að útvega plöntur og styrkja einstaklinga og félög við að girða reiti til skógræktar.

Þessi fundur mun sennilega hafa verið auglýstur sem útbreiðslufundur því næst er kannað, hve margir vilji ganga í félagið Það voru sex, sem óskuðu inngöngu, þar á meðal var undirritaður og kona hans. Bersýnilega átti einnig að geta um eldri félaga, sem voru mættir, en það mun hafa farist fyrir. Þótt fundarmenn væru ekki fleiri, tóku nokkrir til máls og sögðu frá hvað gert hafði verið og hvöttu til frekara starfs.

Þá fór fram stjórnarkosning, sem fór þannig: Jón Ísberg fékk 15 atkvæði, Dómhildur Jónsdóttir 11 atkvæði, og Gísli Pálsson, Páll Jónsson og Holti Líndal fengu 10 atkvæði hver. Þegar fundarstörfum var lokið var sýnd kvikmynd um skógrækt í Ameríku.

Eftir aðalfundinn var svo haldinn stjórnarfundur og skiptu stjórnarmenn með sér verkum. Gísli Pálsson var kosinn formaður, Jón Ísberg varaformaður, Páll ritari, Dómhildur Jónsdóttir gjaldkeri og Holti Líndal meðstjórnandi.

Þessi aðalfundur 1960 markar upphaf að endurreisn skógræktarfélagsins. Næsti stjórnarfundur er svo 14. okt. sama ár í Höfðakaupstað. Voru allir stjórnarmenn mættir. Undir 2. lið dagskrár segir svo: „Þá skýrði formaður svo frá, að þeir Jón Ísberg ásamt með Sigurði Jónassyni, skógarverði, ferðuðust í byrjun septembermánaðar um nokkur svæði hér í sýslunni til athugunar á stað fyrir héraðsskóg. Ferðuðust þeir aðallega um Ásana og komust lengst að Blöndudalshólum, en þangað var aðallega farið til þess að skoða þar skógarlund. Komið var á staði s.s. í Sauðanesi, - í Tindalandi og - í Kagaðarhólslandi.

Stjórnin ræddi þau viðhorf, sem þurfa að vera í skógræktarmálum hér m.a. að fá nægilega stórt og gott land á góðum stað til félagsins. Stjórnin fól þeim Gísla Pálssyni og Jóni ísberg, sýslumanni, að vinna að máli þessu og komast að þeim bestu úrlausnum, sem hægt er að ná og hentug eru fyrir félagið –". Fleira var rætt, sem ekki snertir þetta mál sérstaklega.

Aftur er stjórnarfundur haldinn 10. maí árið eftir. Aðeins mættu þrír stjórnarmenn. Þau Dómhildur og Páll mættu ekki. Aðalefni þess fundar var að velja menn til Noregsfarar þá um sumarið. En svo segir: „Rætt var um skógræktarmálefni, en þar sem ekki voru mættir fleiri þá voru engar ályktanir gerðar-".

Næsti fundur er svo haldinn á heimili Jóns Ísberg 29. okt. 1961 og eru allir stjórnarmenn mættir. Ennfremur Steingrímur Davíðsson, fyrrv. skólastjóri á Blönduósi. Orðrétt segir svo:

„1. Formaður bauð fundarmenn velkomna og skýrði frá fundarmálefni og gaf síðan Steingrími Davíðssyni orðið.

Steingrímur Davíðsson las síðan upp gjafabréf til skógræktarfélagsins frá þeim hjónum, Helgu Jónsdóttur og honum, þar sem þau afhenda Skógræktarfélagi Austur-Húnavatnssýslu eignarjörð sína, Gunnfríðarstaði í Svínavatnshreppi, A-Hún., að gjöf með nokkrum skilyrðum, sem tekin eru fram í gjafabréfinu, sem Steingrímur afhenti stjórninni nú á fundinum.

Stjórn félagsins þakkaði hina höfðinglegu gjöf þeirra hjóna og vill fyrir sitt leyti vinna að því, að þær óskir og vonir rætist, sem gefendur óska og er einnig sérstakt áhugamál skógræktarfélagsins

Á þessum fundi fól stjórnin formanninum að útvega þá strax girðingarefni og fjármagn. Það hefir tekist og einnig að fá menn til þess að girða, því á næsta fundi stjórnarinnar, sem haldinn var að Höskuldsstöðum 14. mars var rætt um pöntun trjáplantna félagsins fyrir félagsmenn í sýslunni og bætt við „Auk þess þarf að athuga um pöntun sérstaklega í girðingu félagsins að Gunnfríðarstöðum".

Ég ætla nú að skjóta því hér inn á milli tilvitnana í fundargerðir, að þegar við Gísli á Hofi og Sigurður skógarvörður vorum að skoða hugsanleg skógræktarsvæði munum við hafa minnst eitthvað á Gunnfríðarstaði. Sigurður var vantrúaður á svæðið m.a. vegna þess að það lá á móti norðaustanáttinni. Frá Gunnfríðarstöðum séð liggur þjóðvegurinn austan Blöndu fram Langadal, en þeir, Gunnfríðarstaðir, eru ekki taldir til Langadals heldur Bakása. Oft er þræsingur eða kaldi í Út-Langadal, þótt lygnt og gott veður sé í framdalnum. Hvað sem við höfum rætt um veðráttuna á Gunnfríðarstöðum þá festist þetta í minni mínu af eftirfarandi ástæðum. Það mun hafa verið vorið 1963 að ákveðið var að safna fólki saman til þess að gróðursetja að Gunnfríðarstöðum. Gísli á Hofi og Hallgrímur í Hvammi, báðir gildir bændur í Vatnsdal, mættu til leiks, en enga var hægt að fá á Blönduósi, þrátt fyrir að allnokkrir hefðu ætlað að fara, en þar var þá norðaustan þræsingur og súld. Ég lagði því ekki hart að mönnum að koma með fram að Gunnfríðarstöðum. En Gísli og Hallgrímur vildu ógjarnan fara fýluför, svo við ákváðum að fara og ég tók með tvo syni mína 10 og 11 ára til þess að hjálpa okkur við gróðursetninguna. Eins og áður segir var leiðindaveður og hélst það alveg fram fyrir Kagaðarhól, en þar er sveigt yfir hálsinn að Gunnfríðarstöðum. En þetta var nú útúrdúr.

Við gróðursettum svo fyrstu plönturnar vorið 1962. Sigurður skógarvörður kom til þess að kenna okkur tökin og leiðbeina okkur. Svo vel vildi til að Steingrímur gat komið því við að gróðursetja fyrstu plönturnar. Alls voru settar niður þetta vor 17.650 trjáplöntur. Vorið 1963 urðu þær 25.125, 1964 um 21.900 og 1965 um 9.340 eða þessi fjögur ár um 75 þúsund plöntur.

Landið sem gróðursett var í var gömul mýri, sem verið var að þurrka upp, en mikill vegarskurður hafði verið grafinn fyrir ofan það land, sem fyrst var tekið til skógræktar. Það hafði verið ógirt og þrælbeitt af sauðfé og hrossum. Byrjað var á að plægja hluta af landinu og sett þar niður. Allt eftir fyrirsögn Skógræktarinnar. Fyrstu tvö árin gekk allt vel meðan jörðin var að jafna sig eftir ofbeit undanfarinna ára. En þriðja árið 1964 var okkur ekki farið að lítast á blikuna. Grasspretta var það mikil. Okkur var ráðlagt að reyta frá plöntunum og fengum við unglinga til þess. Þau unnu að þessu í um tvær vikur. Svo eftir um þrjár vikur fór ég að skoða árangurinn og þá kom áfallið. Allt var komið í kaf í grasi. Ég hafði samband við Hákon skógræktarstjóra og bað hann að koma, sem hann gerði og var alveg forviða á öllum þessum grasvexti. Sagðist aldrei hafa séð annað eins og kvaðst vilja kalla til sérfræðing Skógræktarinnar í þessum málum, Einar Sæmundsen. Hann kom og var undrandi á öllu grasinu. En þeir gátu lítið gert. Eiturefni voru reynd en það gekk ekki vel. Við vorum ráðalaus og Skógræktin líka. Þetta áfall dró verulega úr okkur kjarkinn svo árið 1965 voru eins og áður segir „aðeins" gróðursettar 9.340 plöntur. Næstu tvö árin virðist svo ekkert hafa verið gróðursett, sem ef til vill getur hafa stafað af því, að girðingin var orðin full eða því sem næst. Þetta kemur fram á aðalfundinum 1965, en þá er hvatt til að girða nýtt svæði. Svo var byrjað aftur í smáum stíl 1968 eða 3.840 plöntur, sem jókst næstu árin. Girðingin mun hafa verið stækkuð 1968 eða 1969, en þá var farið að sjá árangur af öllu þessu basli og menn orðnir bjartsýnni

Baráttan við grasið hélt áfram og á aðalfundi 13. okt. 1967 kom fram „- að pappalepparnir, sem settir voru kringum trjáplönturnar að Gunnfríðarstöðum hafa reynst mjög vel ...“

Fyrstu tvö árin var alveg notast við sjálfboðaliða en 1964 og eftir það var að verulegu leyti keypt vinnuafl. Var aðallega um að ræða heimilisfólkið á Ásum, en jörðin Hamar var þá í eyði. Hana keypti síðar Erlingur Ingvarsson frá Ásum, einn þeirra systkina sem lagði okkur lið við gróðursetninguna og síðar fyrsti skógarbóndinn í Húnaþingi að ég best veit. Þar naut hann þess hve vel skógræktin á Gunnfríðarstöðum hefir gengið.

Hér ætla ég að hætta og láta aðra um framhaldið. Af framansögðu sést hverjir frumherjarnir voru, væntingar þeirra og vonbrigði, sem svo síðar urðu gleðitíðindi. Haraldur Jónsson tók við formennsku í skógræktarfélaginu 1976. Hann og Ebba kona hans unnu mikið starf við skógræktina á Gunnfríðarstöðum og eigum við þeim mikið að þakka. Honum eða þeim hjónum er að þakka asparlundinn í gamla túninu. Ég vil ekki á nokkurn hátt gera lítið úr starfi þeirra, en þótt einn sé lofaður fyrir gott starf, þá er rétt að annarra sé einnig getið, sem að hafa unnið.

Ef myndirnar, sem fylgja grein Sigurðar, eru skoðaðar sést vegurinn fram að Hamri greinilega Landsvæðið þar fyrir neðan var fyllt á fjórum árum með því sem næst um 75 þúsund plöntum. Það tók sinn tíma fyrir þær að hafa sig upp úr grasinu, en það tókst og segir sögu frumherjanna betur en nokkuð annað.

Þetta framlag er hluti „sögunnar bak við söguna“. Það sem hér er sagt er byggt á fundargerðum skógræktarfélagsins og því um staðreyndir að ræða, sem hægt er að treysta og vitna til, ef því er að skipta. Ég hefi ekki flíkað nöfnum neitt að ráði, en ef einhver telur þess þörf, er auðvelt að bæta úr því síðarmeir. Öll skjöl skógræktarfélagsins eru varðveitt á Héraðsskjalasafni Austur-Húnvetninga, Blönduósi, og öllum aðgengileg sem skoða vilja.

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ÞORKELL JÓHANNESSON

Reynsla af víði við erfiðar aðstæður

- Ágæti viðju og myrtuvíðis-

Árið 1985 festum við hjónin okkur sumarbústaðarland (rúmlega 4 ha) í landi Gaddstaða, skammt austan við Hellu og niður með Hróarslæk (Gaddstaðaland nr. 11). Árið áður hafði verið reynt að græða landið (og löndin þar í grennd), en það tókst misvel. Þegar við komum að, mátti því telja, að þriðjungur landsins væri með öllu ógróinn sandur.

Vestan við mitt landið er brún, og hallar af henni til austurs að annarri lægri brún. Frá þessari eystri brún hallar svo landinu að Hróarslæk. Var það land vel gróið. Milli brúnanna er nokkurs konar skál. Í skálinni var landið bert ofanvert, sæmilega gróið hið neðra, en hálfgróið eða tæplega það um miðju. Þar settum við sumarbústað sumarið 1987 og nefndum í Litla Odda eftir fornbýli þar um slóðir. Árið eftir girtum við af landið milli brúna (0,7 - 0,8 ha), en létum hitt vera beitiland handa hrossum.

Eitt hið fyrsta, sem við vildum takast á við, var að klæða með gróðri bera brekkuna ofan bústaðarins. Samhliða þessu var nauðsynlegt að koma upp skjólbeltum á útmörkum trjáræktarsvæðisins.

Fátt um góð ráð

Erfitt var að fá ráðgjöf um hvernig að gróðursetningu skyldi standa eða hverjar plöntur skyldi nota. Sumir töldu meira að segja skógrækt með öllu vonlausa á þessu svæði. Smám saman komumst við samt upp á lag með að grafa skurði í sandinn eða flóra fyrir plöntur í lundum og fylla af hrossataði og mold áður en gróðursett yrði. Stundum var þessi vinna svo harðsótt, að nota þurfti vegavinnuhaka til þess að undirbúningur tækist svo sem að var stefnt. Hugmyndin var að koma upp skjóli umhverfis ræktunarsvæðið með marglaga og óklipptum skjólbeltum og klæða brekkuna í skálinni ofan sumarbústaðarins með lággróðri.

Skjólbeltin

Einhver mun hafa sagt okkur að nota viðju (*Salix myrsinifolia*) þar, sem sandurinn og sandsteinninn var verstur, en frekar alaskavíði (*Salix alaxensis*), væntanlega klóninn 'Gústu' og síðar (samkvæmt sérstakri ábendingu) klóninn 'Hrímu', í jarðveg, sem var betri og auðunnari. Á köflum höfum við (einnig samkvæmt ábendingu) sett jörfavíði (*Salix hookeriana*), en segja má, að hann sé fallegastur þessara þriggja víðitegunda. Við settum svo fyrstu skjólbeltin upp sumarið 1988.

Nú að liðnum 12 árum fer ekki milli mála, að viðjubeltin hafa staðið sig jafnbest. Þau kelur langminnst og standast tiltölulega vel maðk og hafa að jafnaði þéttasta laufþekju. Þá hafa viðjubeltin allt að því ótrúlegt brotþol undir jafnvel hörðum sköflum, sem margbrotið myndu hafa vöxtulegt birki, og rísa á vorin úr sköflum lítt brotin og laufgast á ný. Viðjan vex að vísu hægar en hinar víðitegundirnar og hún mætti vera vindþolnari og sennilega einnig saltþolnari. Þá höfum við tekið eftir því, að hross fúlsa við viðju, en eru sólgin í alaskavíði (myndir 1 og 2) og að nokkru leyti í jörfavíði. Er þetta ótvíræður kostur, ef menn vilja sameina trjárækt og hestamennsku líkt og

Mynd 1. Ysta röð fimmlaga viðjuskjólbeltis á útjaðri ræktunarsvæðisins skammt vestan við akveginn að sumarbústaðnum. Við staurinn til vinstri á myndinni eru oft festir hestar til þess að leggja á þá reiðver. Engu að síður er laufið óbitið að kalla.

við höfum reynt. Raunar skortir rannsóknir á sókn hrossa í trjálauf (sbr. viðauka).

Þess skal getið, að við höfum haldið skjólbeltunum við með árlegri áburðargjöf (venjulega Græðir 6 eða 7) og munum gera svo enn um sinn.

Brekkan

Haustið 1987 fengum við með okkur austur skrúðgarðyrkjumeistara til þess að reyna að skipuleggja gróður í sandbrekkunni ofan bústaðarins. Úr varð að hafa þar eina 16-18 víðilundi með 15-40 plöntum hvern og með það fyrir augum, að þeir gætu síðar vaxið saman líkt og í náttúrlega heild. Við hófumst einnig handa við þetta sumarið 1988.

Eftir þessari grófu skissu settum við upp 10 lundi með nokkuð mismunandi loðvíði *(Salix lanata*) í brekkunni þannig, að þríhyrna var opin upp brekkuna frá miðjum bústaðnum. Neðarlega í þríhyrnuna settum við jarðlægan fjallavíði (*Salix arctica*) ásamt umfeðmingi (*Vicia cracca*) með það í huga, að víðirinn og umfeðmingsgrasið yxi upp þríhyrnuna. Allra neðst settum við svo lund með eini (*Juniperus communis*).

Loðvíðinum hefur farnast mjög misjafnlega vel. Hann er greinilega mjög mismunandi næmur gegn maðki og kali. Í hretinu snemma í júní 1997, þegar jörð náði að hvítna um stund, létu flestir lundirnir á sjá, en einn þó áberandi mest. Hæsti lundurinn er nú orðinn rúmlega 1,5 m á hæð (mynd 3), og þeir ná nú orðið sums staðar saman.

Sitt hvorum megin við loðvíðilundina settum við svo alls sjö lundi, fjóra með myrtuvíði (*Salix myrsinites*) og þrjá með bjartvíði (*Salix candida*) og loks einn með lappavíði (*Salix lapponum*). Lappavíðirinn er nú í grennd við vöxtulegt birki og hefur aldrei vaxið betur en í sumar.

Eins og margir hafa haldið fram er bjartvíðir meðal fegurstu víðitegunda, þegar vel tekst til. Okkar reynsla af honum er því miður nokkuð á sömu lund og Jóhann Pálsson lýsir í grein sinni í Skógræktarritinu 1997 (hann segir, að honum hætti sunnanlands „til að fara of snemma af stað á vorin og lætur þá á sjá ef síðbúin vorhret skella á“).

Myrtuvíðir - Vanmetin víðitegund?

Myrtuvíði kelur næstum ekki og þurrkur bítur lítið eða ekki á hann, né skordýr eða sveppir svo að teljandi sé. Þar að auki myndar myrtuvíðir fallegar og þéttar breiður, er kæfir allt gras eða aðrar jurtir, sem upp kunna að koma í lundum (mynd 4). Þá hefur myrtuvíðir áberandi ilm, sem er mestur síðsumars eða á haustin, þegar laufið er að skipta um lit og verða brúnt (myrtuvíðir fellir laufið fyrst að vori, þegar hann laufgast á ný). Ilmur þessi er a.m.k. á stundum eins og birki hafi verið brennt í ofni og hann sérstaklega mikill í góðviðrinu nú í haust.

Í yfirlitsgrein sinni um víði og víðiræktun á Íslandi í Skógræktarritinu 1997 telur Jóhann Páls-

Mynd 2. Vatnstunna undir marglaga alaskavíðibelti (Gústa) á útjaðri ræktunarsvæðisins skammt austan við akveginn að sumarbústaðnum. Hrossin koma oftast nokkrum sinnum á dag að tunnunni að fá sér að drekka. Þau „klippa“ að því loknu alaskavíðinn og éta hann með sýnilegri velþóknun. Skjólbeltin á myndum 1 og 2 eru í beinu framhaldi hvort af öðru og einungis vegurinn að bústaðnum er á milli.

Mynd 3. Hæsti loðvíðirunninn er orðinn rúmlega 1,5 metrar að hæð. Yfir þakið á sumarbústaðnum sér í brekkuna handan Hróarslækjar og efst í Selalækjarlandi. Þar fyrir handan sér á fjallið Þríhyrning, sem frægt er úr Njálu og setur umtalsverðan svip á Rangárvelli.

Mynd 4. Lundur með myrtuvíði, 4-6 árum frá gróðursetningu (pottaplöntur). Lundurinn er mest rúmlega 1 metri að hæð og hann myndar þétta, samfellda breiðu. Bak við manninn, sem á mælistikunni heldur, má eygja birki, sem brotnað hefur undir fönn og kræklast,

Mynd 5. Myndin sýnir myrtuvíðilund um það bil 10 árum frá gróðursetningu (pottaplöntur). Hæstu greinarnar eru 1,6-1,7 metra háar og meðalhæðin er 1,3-1,4 metrar. Undir handlegg mannsins sér á vöxtulegt birki fárra ára gamalt. Við hina hlið mannsins sér á limgerði úr jörfavíði.

son, að myrtuvíðir gæti orðið mest um það bil 1 metri að hæð við bestu aðstæður hér á landi. Þetta er þó alls ekki í samræmi við okkar reynslu, sem bendir til þess, að myrtuvíðir geti orðið 2 metrar að hæð (mynd 5).

Jóhann Pálsson telur enn fremur í grein sinni, að myrtuvíðir geti orðið verðmæt landgræðsluplanta við erfiðustu aðstæður hér á landi. Hvort sem myrtuvíðir er hæfur til landgræðslu við erfiðustu aðstæður eða ekki, er samt full ástæða til þess að gefa þessari harðgerðu víðitegund meiri gaum í þessu skyni en verið hefur.

Að lokum skal þess getið, að bilin milli lundanna margnefndu greru upp með grasi og tilfallandi gróðri vegna umferðar með mold og hrossatað og með lítils háttar hjálp tilbúins áburðar. Við reyndum lúpínu þarna í brekkunni. en hún þreifst ekki í þessu gjörsnauða landi, eftir því sem best varð séð.

(Skrifað í október 2000)

Viðauki

Höfundur hefur um mörg ár haft beitiland (ca 2-2½ ha) fyrir hross á Vatnsenda í Kópavogskaupstað. Hann hefur sjálfur að verulegu leyti ræktað landið og notar það einkum til haustbeitar. Er með tilliti til þessa nú borið á landið 200- 300 kg af tilbúnum áburði síðsumars. Gróska í landinu hefur aukist mjög á síðustu 10 árum eða svo líkt og gildir um margar lendur í grennd við Reykjavík. Aukin gróska á jafnt við beitarjurtir og loðvíði, en þó einkum gulvíði, sem í síauknum mæli vex upp af rótum í landinu. Síðustu 5 ár eða svo hefur sömuleiðis birki byrjað að vaxa í síauknum mæli landinu. Það hlýtur þó fyrst og fremst að vera vegna aðvífandi birkifræs. Hrossin hafa síður en svo truflað þessa þróun, enda virðast þau sneiða fram hjá bæði víðinum og birkinu á ferð sinni um landið. Landið er þannig að breytast úr gras- og mólendi í kjarri vaxið eða hugsanlega skógi vaxið beitiland. Þetta er því hin athyglisverðasta þróun á gróðursamfélagi samfara beit. Þörf er á að rannsaka mun metur í skipulegum tilraunum, hvernig hrossabeit og uppvaxandi kjarrgróður eða skógargróður geta farið saman. Þetta er ekki síst æskilegt í ljósi þess hve hrossaeign er útbreidd og hross mörg í landinu.

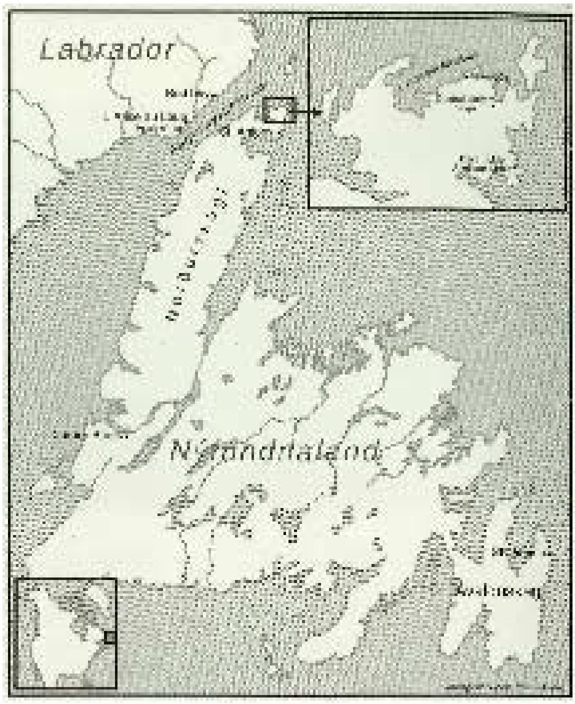
Heimild

Jóhann Pálsson. 1997. Víðir og víðiræktun á Íslandi: Ársrit Skógræktarfélags Íslands.

Þorkell Þorkelsson ljósmyndari tók myndirnar (byrjun ágúst 2000).

SIGURÐUR BLÖNDAL

Eyðimerkur Nýfundnalands og Labrador



„Þar voru þá eyðimerkur einar allt að sjá fyrir þeim og nær hvergi rjóður í.“

Svo er skrifað í XI. kafla Eiríks sögu rauða, þar sem lýst er siglingu Þorfinns karlsefnis, er hann fór einskipa að leita Þórhalls veiðimanns. Lýsingin á við skóglendi einhvers staðar við mynni Lárensflóa í Norðaustur-Kanada. Orðið *eyðimörk* merkir hér greinilega samfelldan skóg, undirskilið engar mannabyggðir. Íslendingar vita, að þetta orð hefir nú snúist upp í andhverfu sína á sama hátt og orðið *holt,* sem í fornu máli merkti skógarteig Hefir reyndar varðveist óbreytt í þeirri merkingu í norsku.

Mér datt í hug að benda á þessa fornu merkingu orðsins, þegar ég ætla að lýsa fyrir lesendum „Skógræktarritsins“ tiltekinni gerð af skógi á Nýfundnalandi og Labrador, sem ætíð hlýtur að vera og verða laus við mannaferðir. Við Þröstur Eysteinsson vorum þarna í september síðastliðnum, sáum þessa merkilegu gerð skógar, sem vakti eilífa undrun okkar, hvar sem við sáum hann.

Ég ætla að reyna að lýsa stuttlega og bregða upp nokkrum ljósmyndum af „tuckamore“ eins og hann heitir á máli þarlendra Þetta er ofurþétt og lágvaxið kjarrþykkni af barrskógi sem vex m.a. á Norðurskaga Nýfundnalands og strönd Labradorskaga við Fagureyjarsund (Strait of Belle Isle), þar sem við Þröstur fórum um. Nutum raunar sums staðar samfylgdar Páls Bergþórssonar veðurfræðings.

Við eigum ekki nafn á íslensku yfir fyrirbærið „tuckamore“, en okkur Þresti kom saman um, að einfaldast væri að kenna það við aðaltrjátegundina, balsamþin *(Abies balsamea* (L) Mill.), og nefna það balsamkjarr, á sama hátt og við tölum á íslensku um birkikjarr og víðikjarr, eftir því hvor tegundin má sín meira. Aðrar trjátegundir í þessu kjarri geta verið svartgreni *(Picea mariana* (Mill.) BS.P.), hvítgreni *(Picea glauca* (Moench) Voss), mýralerki *(Larix laricina* (DuRoi) K.Koch). Ennfremur grænölur *(Alnus crispa* (Ait.) Pursh) og örsjaldan næfurbjörk *(Betula papyrifera* var .Marsh.).

Ég held aðstæðunum, þar sem þessi sérkennilegi skógur vex, sé best lýst með eftirfarandi klausu úr nýlegu riti, sem ríkisstjórn Nýfundnalands og Labrador [eitt af fylkjunum í Kanada] gaf út 1996 um 20 ára skógræktaráætlun 1998-2015. Klausan lýsir svæði á strönd Labradorskaga, sem nefnist „Forteau Barrens“, eða auðnirnar við Forteau:

„Þetta vistsvæði er á suðausturhorni Labrador og liggur með Fagureyjarsundi. Lágar hæðir eru þaktar grenikjarri, krækiberjamóum og hallamýrum. Þarna eru sterkir vindar og stormar algengir, vegna þess að svæðið er svo nálægt Fagureyjarsundi. Vaxtartíminn er 100-120 dagar.

Vöxtur trjáa er takmarkaður, þar sem á eitt leggjast vindur, blautur jarðvegur og tíðir skógareldar. Svartgreni og mýralerki geta náð 10-12 m hæð aðeins meðfram ám, þar sem jarðvegur er sæmilega þurr.“

Að þessu skrifuðu finnst mér rétt að gefa lesendum ofurlitla hugmynd um hagtölur skógarins í fylkinu, af því að balsamkjarrið er aðeins lítill hluti hans. Þessar tölur eru í rammagreininni hér við hliðina.

Í rammagreininni sést, að 63% skóglendis í fylkinu er talið ónýtanlegt. Hluti af því er lágvaxna kjarrþykknið, sem nefnt var hér að framan. En engar upplýsingar eru um stærð þess sérstaklega. Hæð þess er frá hálfum m upp í svona 5-6 m. Það er svo þétt og flækt, að telja má nær ófært að komast um það.

Engu að síður datt mér í hug að reyna að brjótast í gegnum það. Þetta var í námunda við einmana sveitakirkju skammt norðan við bæinn St. Anthony, sem er stærsti bærinn nyrst á Norðurskaga.

Ég braust um í hartnær eina klukkustund, var gersamlega týndur og villtur, því að þarna var kjarrið 4-5 m hátt. Þröstur var ekki langt frá og beið þess í nokkurri eftirvæntingu, hvernig mér reiddi af. Ég bjargaðist af því að við gátum kallast á og ég gat brotist áfram á hljóðið frá honum, uns ég var skyndilega kominn í dálítið rjóður, sem hann stóð í. Við áætluðum, að ég hefði farið eina 50 m!

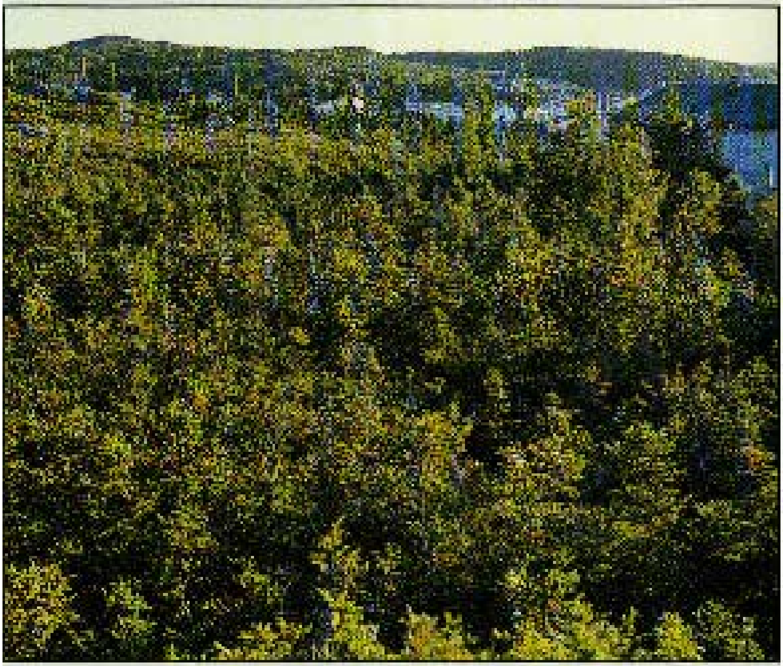
Þetta var satt að segja ein minnisstæðasta skógarferð mín. Nú orðlengi ég þetta ekki frekar, en læt nokkrar myndir lýsa betur kjarrinu en orð fá gert.

Nýfundnaland og Labrador - hagtölur um skóginn

Íbúafjöldi	541.559	
Flatarmál fylkisins	40,6	milljónir ha
Flatarmál þurrlendis	37,2	milljónir ha
Flatarmál skóglendis	22,5	milljónir ha
Þjóðgarðar (í fylkiseigu)	439.500	ha
Skóglendið		
Eigendur		
Fylkið	99%	
Einkaaðiljar	1%	
Samsetning skógarins		
Barrskógur	91%	
Blandaður skógur	8%	
Laufskógur	1%	
Leyfi að fella árlega (1997)	2,6	milljónir ha
Fellt rúmtak viðar (1998)	1,9	milljónir m3
Rjóðurfellt flatarmál (1998)	17.408	
Aflaufað af skordýrum (1999)	35.121	
Eytt af skógareldi (1998)	40.226	
Heimild: The State of Canadas Forests 1999/2000		
Nýtanlegur skógur	8,4	milljónir ha eða 37%
Ónýtanlegur skógur	14,6	milljónir ha eða 63%
Heimild: 20 Year Forestry Development Plan 1996-2015		

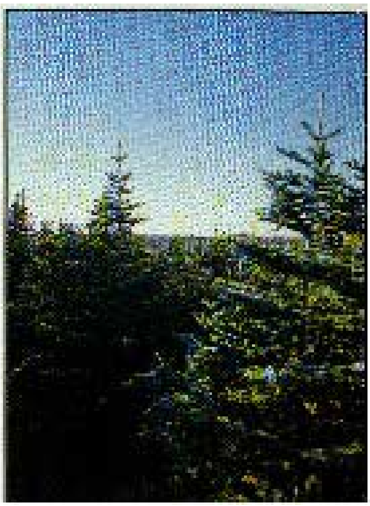
Myndirnar, sem greinarhöfundur tók 18.-26. sept. 2000.

Á Norðurskaga Nýfundnalands



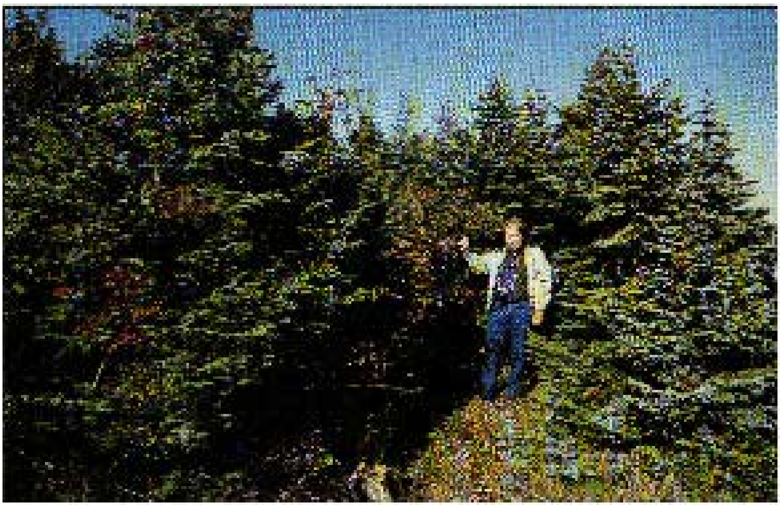
1. mynd. Kjarrið á hæðinni ofan við hótelið í St. Anthony. Hér er það talsvert blandað. Mikið af hvít- og svartgreni.

2. mynd. Kræða af grænelri í skógarjaðri skammt frá Central United Church fyrir norðan-St.Anthony.



3. mynd. Á sama stað og á 2. mynd. Horft yfir balsamkjarrið, sem greinarhöfundur braust í gegnum.

4. mynd. Horft inn í kjarrið á 3. mynd.



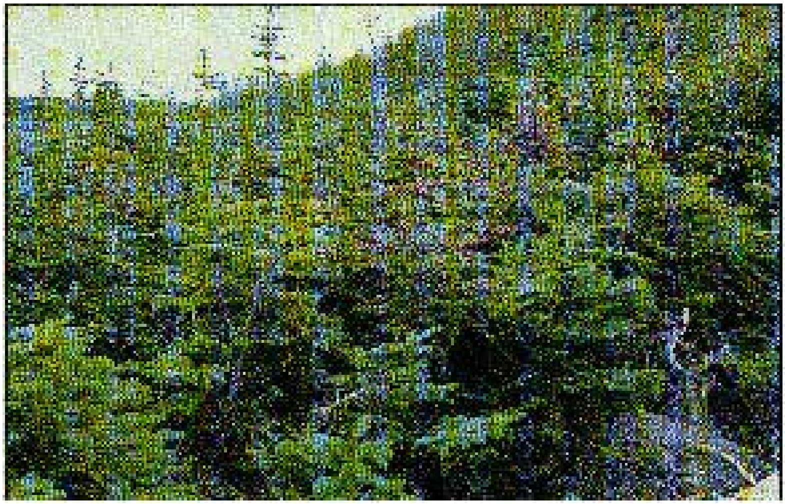
5. mynd. Þröstur í rjóðrinu, þar sem hann beið greinarhöfundar.

6. mynd. Balsamkjarr á hól rétt við Dark Tickle Anglican Church skammt norðan við St. Anthony. Dæmi um það, hve þétt balsamþinurinn getur staðið. Hann er svo frjósamur, að iðulega finnast 50-100 þúsund plöntur á ha í þinskógi.

7. mynd. Sæbarið balsamkjarr á sjávarbakkanum rétt hjá Leifsbúðum í L'Anse aux Meadows.

8. mynd. Balsamkjarr í brekkunni skammt ofan við L'Anse aux Meadows.

9. mynd. Horft inn í kjarrið við stíginn niður að L'Anse aux Meadows.



Á Labradorströnd skammt frá bænum L'Anse au Loup

10. mynd. Í forgrunni stendur Alexander Robertson í kjarri af mýralerki, en í baksýn er skógarhlíð með „bylgjuskógi“ – „Bylgjuskógar eru sérstæð dæmi um vindmótun í skógi.

Þessir skógar eru aðeins á örfáum stöðum í heiminum. Þeir eru á Nýfundnalandi, Suður-Labrador, á nokkrum stöðum í fjöllum Norðaustur-Bandaríkjanna og í Japan“, skrifar Alexander Robertson í greininni „Tré og vindur“ í Ársritinu 1989, bls. 39.
Sjá nánari lýsingu á fyrirbærinu þar.

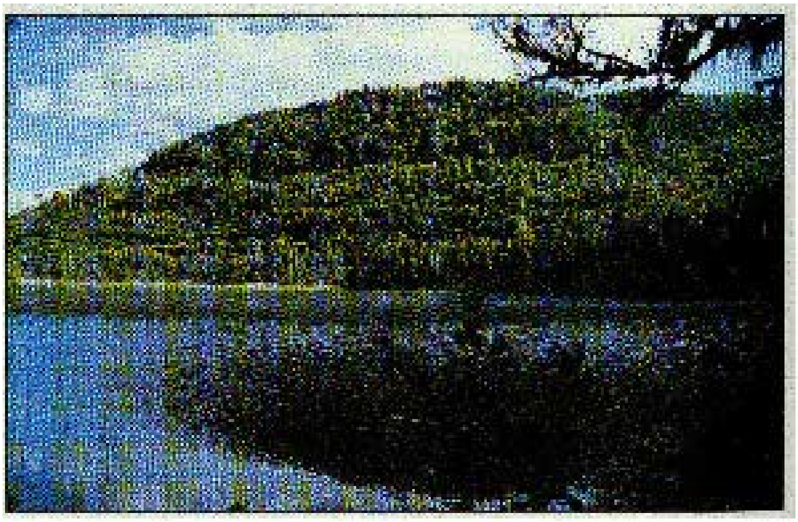
Á vesturströnd Nýfundnalands

Hér er skógurinn orðinn hávaxnari en balsamkjarrið á Norðurskaga Hann er samt hið versta ótræði, en er á mörkum þess að vera nýtanlegur. þar sem hann er lakastur.

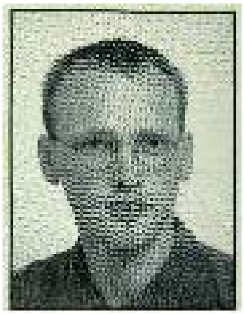
11. mynd. Jaðar af aðallega svartgreni með nýgræðingi af balsamþin í skógarbotni.

12. mynd. Gamall svartgreniskógur við Cooks Marsh skammt norðan við borgina Corner Brook.

13. mynd. Við Cooks Marsh: í baksýn fullorðinn skógur, en framan við hann á miðri mynd er sjálfgróinn ungskógur, kominn upp eftir rjóðurfellingu.



HREINN ÓSKARSSON



Hvenær á að bera á?

Tímasetning áburðargjafar á nýmörkum

INNGANGUR
Rannsóknir hafa leitt í ljós jákvæð áhrif áburðargjafa á vöxt og líf trjáplantna fyrstu árin eftir gróðursetningu (Hreinn Óskarsson o.fl. 1997, Ása L. Aradóttir og Járngerður Grétarsdóttir 1995, Jón Guðmundsson 1995). Þessar jákvæðu niðurstöður hafa leitt til þess að áburðargjöf er orðin fastur liður við upphaf skógræktar, að minnsta kosti í allflestum skógræktarverkefnum. Ýmsar spurningar hafa vaknað varðandi notkun tilbúins áburðar í nýskógrækt, s.s. hver eru áhrif áburðar á frostþol og næringarástand trjáplantna, hvaða áhrif hefur áburðargjöf á svepprótamyndun, hversu lengi vara áhrif áburðargjafar og á hvaða tíma árs hagkvæmast er að bera á? Um þessar mundir er unnið að því að leita svara við þessum spurningum á Rannsóknastöð Skógræktar á Mógilsá og er niðurstaðna að vænta á næstu misserum.

Í júní 1998 voru settar á stofn tilraunir á þrem stöðum á landinu sem miðuðu að því að kanna áhrif mismunandi tímasetninga áburðargjafa á líf og vöxt birkis og sitkagrenis á mismunandi jarðvegsgerðum. Eftirfarandi rannsóknaspurningar voru settar fram:

1) Hvaða dreifingartími áburðar gefur minnst afföll og mestan vöxt?
   a) áburðargjöf við gróðursetningu (snemma sumars),
   b) um miðjan júlí,
   c) seint í ágúst,
   d) ári eftir gróðursetningu.

2) Er munur á svörun trjátegunda? Þær tegundir sem eru bornar saman eru:
   a) birki (*Betula pubescens* Ehrh.),
   b) sitkagreni (*Picea sitchensis* (Bong) Carr.),
   c) rússalerki (*Larix sukaczewii* Dylis).
   d) stafafura (*Pinus contorta* Dougl. Ex. Loud.).

Jarðvegur á einu af tilraunasvæðunum, Végeirsstöðum, reyndist vera mun blautari en við var búist og stóð vatn í rásum í hluta tilraunarinnar. Því eru niðurstöður hennar vart marktækar og verða ekki birtar hér.

Áhugasömum lesendum er bent á Rit Mógilsár nr. 1 þar sem nánar er fjallað um þessar tilraunir og niðurstöður þeirra

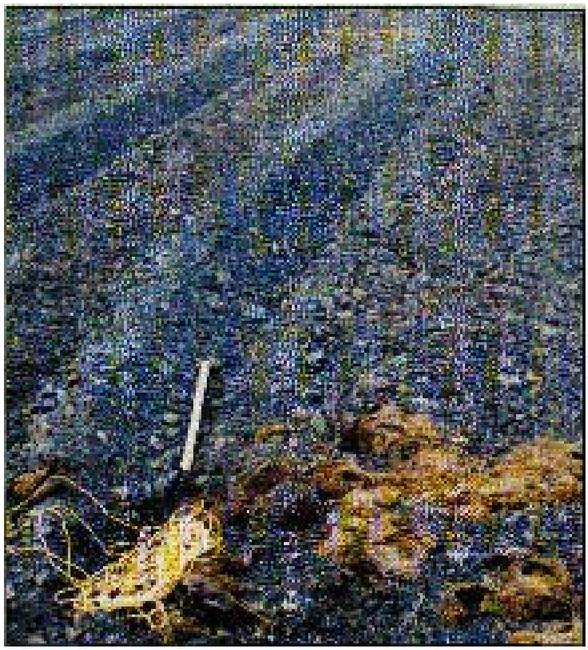
AÐFERÐIR
Tilraunirnar sem notaðar eru í þessari rannsókn eru á tveim stöðum; á Markarfljótsaurum og í Kollabæ (1. tafla). Aðeins átta km eru milli tilraunastaðanna, og veðurfar því ekki ósvipað, en

1. tafla. Lýsing á tilraunasvæðunum.

	Markarfljótsaurar	Kollabær
Staðsetning	63°40.158'N & 20°00.554'V	63°44.758'N & 20°03.205'V
Hæð yfir sjó	60m	um 110 m
Meðalhiti júní-september[1]	10,1°C	10,1°C
Meðalúrkoma[2]	1015 mm	1015 mm
Lýsing	Gróður- og skjóllausir áraurar með stöku krækiberjalyngi og mosa í lægðum. Vatn rann síðast yfir svæðið fyrir tæpum 60 árum.	Dæmigerður fokjarðvegur þakinn þykkum grámosa með heilgrösum milli þúfna.

[1] Meðaltal áranna 1997-1999 á Hellu á Rangárvöllum (upplýsingar frá Veðurstofu Íslands)
[2] Meðaltal áranna 1997 og 1998 á Sámsstöðum (upplýsingar frá Veðurstofu Íslands)

1. mynd. Hluti tilraunar í Kollabæ í Fljótshlíð. Plönturnar voru gróðursettar í miðju plægðrar rásar.



2. mynd. Tilraunasvæðið á Markarfljótsaurum áður en gróðursetning hafði farið fram.

jarðvegur og gróðurfar eru mjög ólík (1. og 2 mynd). Á báðum tilraunastöðum voru rásir plægðar með einskeraplógi og gróðursett var í miðju rásanna með pottiputki gróðursetningarstafnum (geispa). Tilraunin hófst í júní 1998 með því að gróðursettar voru eins árs (1/0) bakkaplöntur ræktaðar í Fossvogsstöðinni/Barra hf. Þær tegundir og kvæmi þeirra sem notuð voru í sunnlensku tilraununum, eru ilmbjörk *(Betula pubescens* Ehrh.) af kvæminu 'Embla', sitkagreni (Picea *sitchensis* (Bong.) Carr.) af Seward kvæmi og stafafura (*Pinus contorta* Dougl. Ex. Loud.) af Tutshi Lake eða Careross kvæmi. Framleiðandi furuplantnanna gat ekki veitt upplýsingar um hvort kvæmið hefði verið selt.

Áburði var dreift umhverfis plönturnar á u.þ.b. 15-20 cm hringferil. Áburðarblandan Gróska II (Áburðarverksmiðjan hf.) var notuð í tilrauninni. Gróska II er blanda af eingildu ammóníum fosfati (9-42-0) á auðleystu formi og Osmocote 32-0-0 (Scotts & Sons Ltd.), þar sem um helmingur köfnunarefnisins er á seinleystu formi. Þrettán grömmum af þessari blöndu var dreift í kringum hverja plöntu. Tilraunameðferðir voru: a) áburðargjöf við gróðursetningu, b) um miðjan júlí, c) seint í ágúst og d) ári eftir gróðursetningu. Engar viðmiðunarplöntur, þ.e. plöntur án áburðar, voru í tilrauninni. Meginástæður þessa voru að óþarft þótti að leita svara við spurningunni um hvort munur væri á lífi og vexti áborinna og óáborinna plantna, þar sem nú þegar hefur verið sýnt fram á að áburðargjöf bætir líf og vöxt (Hreinn Óskarsson o.fl. 1997). Einnig var leitast við að draga sem mest úr kostnaði og tilraunaliðum því fækkað. Til að gefa einhverja hugmynd um vöxt og líf óáborinna plantna verða hér á eftir birt gögn um vöxt birkis úr annarri tilraun sem er við hlið tímatilraunanna og var gróðursett á nákvæmlega sama tíma með samskonar birki og notað var í hinni tilrauninni.

Tilraunin er blokkartilraun með fjórum endurtekningum (blokkum). Meðferðum og tegundum er raðað tilviljanakennt upp innan blokkanna (Randomized block design). 20 plöntur eru af hverri meðferð innan blokkar, alls um 920 plöntur á hverjum tilraunastað.

Líf, kal og frostlyfting var skráð á öllum plöntum í tilrauninni. Hæð, sumarvöxtur, mesta breidd krónu, þvermál stofns við jarðvegsyfirborð, ásamt laufstærð voru mæld á 25% tilraunaplantna sem valdar voru af handahófi. Tölfræðileg úrvinnsla var gerð á gögnunum í forritinu SAS (Statistical analysis system) með aðferðinni PROC MIXED sem er fervikagreining með blönduðu líkani (Little m.fl. 1996). Gögnunum hafði áður verið umbreytt svo þau uppfylltu kröfur um normaldreifingu og einsleitni dreifna (e.

3. mynd. a) Greniplanta haustið 1998. Rauðu nálarnar eru merki um alvarlegan næringarskort. Þ.e. plantan dregur næringu úr nálunum til nota í nýjum ársvexti. b) Greniplanta haustið 1999. Nálar sem voru rauðar haustið áður eru fallnar af en plönturnar hafa náð í næringu úr jarðveginum til að mynda nýja sprota og virðast vera að jafna sig á áfallinu sem þær hafa orðið fyrir við gróðursetningu.

homogenity of variance). Töflur voru unnar í Sigma Plot (Sigma-Plot 6.10).

NIÐURSTÖÐUR OG UMRÆÐA

Líf

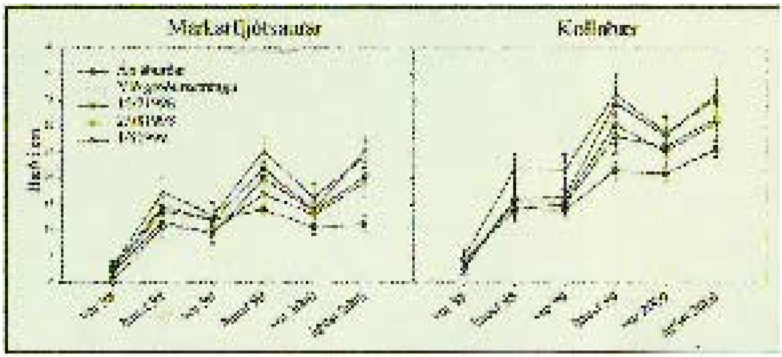
Afföll voru áberandi mikil á stafafuru við fyrstu úttekt haustið 1998 (Hreinn Óskarsson 2000). Eftir fyrsta veturinn voru nánast allar furuplönturnar dauðar á Markarfljótsaurum (>80%) og að-eins um fjórðungur lifandi í Kollabæ. Líklegt er að plönturnar hafi verið gallaðar enda urðu mikil afföll á stafafuru úr þessari framleiðslu víða um Suðurland (Björn B. Jónsson, munnleg heimild). Plönturnar visnuðu eftir gróðursetningu og rótarvirkni virtist afar lítil. Mikil afföll urðu einnig á sitkagreni (um 40 % haustið 2000) og litu plöntur almennt mjög illa út eftir fyrsta veturinn (3. mynd). Ekki var tölfræðilega marktækur munur í lifun milli meðferða. Nær engin afföll urðu á birki (Hreinn Óskarsson 2000).

Hæð og vöxtur

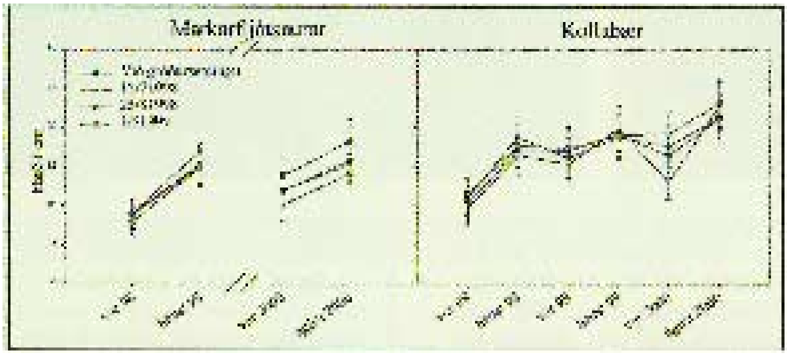
Marktækur munur (95%) var á meðalhæð á milli meðferða hjá birki á Markarfljótsaurum. Munurinn var aðeins marktækur hjá birki fyrsta haustið í Kollabæ. Skemmdir af völdum skara (ísnála) gerðu það að verkum að munurinn í hæð að vori var aldrei marktækur, þ.e. efsti hluti plantnanna sem stóð upp úr snjónum skemmdist (4. mynd) (Hreinn Óskarsson 2000). Áburðargjöf við gróðursetningu gaf mesta hæð hjá birki á báðum tilraunastöðum fyrstu tvö árin, en plöntur sem hlutu áburðargjöf ári seinna náðu svipaðri hæð haustið 2000 (5. mynd). Viðmiðunarplöntur sem aldrei fengu áburð uxu lítið og styttust heldur á Markarfljótsaurum, en lengdust þó aðeins í Kollabæ (5. mynd).

Ekki var marktækur munur á hæð grenis við mismunandi

4. mynd. Birkitoppur stendur upp úr snjónum í vetrarsólinni óvarinn fyrir skara sem olli þónokkrum skemmdum í tilrauninni, sér í lagi á Markarfljótsaurum. Förin í snjónum eru eftir rjúpu sem á það til að narta í endabrum tilraunaplantna, sérfræðingum til mikillar gremju.



5. mynd. Meðalhæð birkiplantna úr hverri meðferð á Markarfljótsaurum og í Kollabæ frá gróðursetningu vorið 1998 fram til ágúst 2000. Mælingar voru gerðar að hausti og hæð að vori ákvarðar byrjunarhæð vaxtarsprota. Lóðréttar línur sýna 95% vikmörk.



6. mynd. Meðalhæð grenis úr hverri meðferð á Markarfljótsaurum og í Kollabæ frá gróðursetningu vorið 1998 fram til ágúst 2000. Mælingar voru gerðar að hausti og hæð að vori ákvarðar byrjunarhæð vaxtarsprota. Hæð var ekki mæld á greni árið 1999. Lóðréttar línur sýna 95% vikmörk.

tímasetningu áburðargjafar. Greni óx hægt og varð fyrir vetrarskemmdum eins og birki (6. mynd). Þó líta plönturnar betur út, en virðast eyða vaxtarorkunni í nýmyndun nála, enda misstu þær megnið af barrmassa sínum strax á fyrsta vetri eftir gróðursetningu (mynd 3a og 3b).

Vetrarskemmdir rýra gildi hæðarmælinga til að meta áburðaráhrif. Einnig er unnt að ákvarða vöxt plantna með því að mæla þvermál við rótarháls og breidd plöntu, þ.e.a.s. mesta þvermál krónu. Nýjar rannsóknir höfundar sýna að mun meiri fylgni (correlation) er milli þvermáls við rótarháls og lífmassa þriggja ára birkiplantna (r = 0,84) en fylgni milli hæðar og lífmassa (r = 0,38). Þar sem lífmassavöxtur er besti mælikvarði á áburðarsvörun má því segja að þvermálsmæling sé betri aðferð til að meta hana en hæðarmælingar.

Þvermál

Þvermál var mælt á úrtaki plantna haustin 1998-2000, þó með þeirri undantekningu að greni var ekki mælt á Markarfljótsaurum 1999. Töluverður munur er milli meðferða hvað varðar þvermál við rótarháls á birki. Þessi munur er sér í lagi áberandi á Markarfljótsaurum og er hann tölfræðilega marktækur (Hreinn Óskarsson 2000). Plöntur sem fengu áburð við gróðursetningu eru gildastar en viðmiðunarplöntur eru mun grennri en við hinar meðferðirnar.

Lítill munur er á meðferðum á greni með þeirri undantekningu að plöntur sem fengu áburð við gróðursetningu eru heldur gildari en hinar. Á Markarfljótsaurum sést þessi munur betur en í Kollabæ (7 mynd)

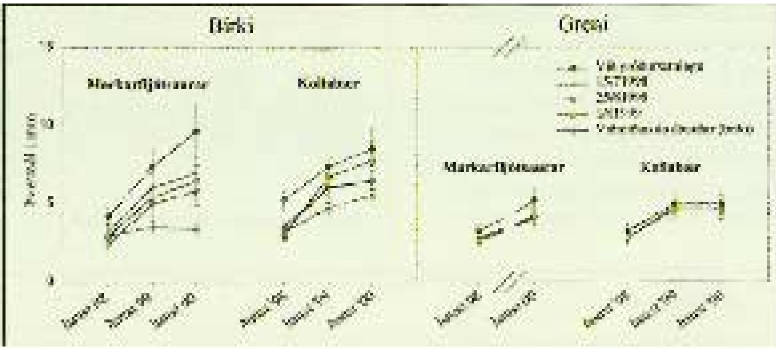
Niðurstöður þvermálsmælinga á birki sýna að mun meiri lífmassavöxtur á sér stað hjá plöntum sem hlutu áburð við gróðursetningu en þegar borið er á á öðrum tímum. Sér í lagi er það áberandi á Markarfljótsaurum að birki vex sáralítið ef ekki er borið á það og jafnvel að það rýrni. Af 7. mynd má einnig sjá að birki sem fær áburð ári eftir gróðursetningu er orðið mun gildara þrem árum eftir gróðursetningu en það sem fær áburð um mitt sumar (15/7'98) eða síðsumars (25/7'98). Rétt er að vekja athygli á því að áburðargjöf á birki hefur alltaf vaxtaraukandi áhrif samanborið við viðmiðunarplöntur (óábornar).

Meðalþvermál laufkrónu var einnig mælt á tilraunaplöntum til að reyna að meta áburðaráhrif. Niðurstöður eru mjög svipaðar og þvermálsmælingarnar, þ.e. plöntur sem fengu áburð við gróðursetningu eru krónumestar og viðmiðunarplöntur krónuminnstar (Hreinn Óskarsson 2000).

ÁLYKTANIR

Hvenær er best að bera á?

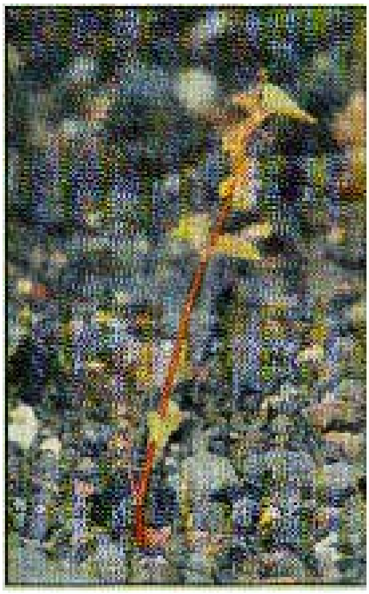
Ekki er mælanlegur munur á milli meðferða hvað varðar afföll eins og fyrr var nefnt og því ekki hægt að fullyrða neitt um hvaða áhrif dreifingartími hefur á lífslíkur. Þó má vekja athygli á því að frostlyfting gæti orðið meira vandamál hjá plöntum sem fá áburð ári eftir gróðursetningu eða síðla sumars en hjá plöntum sem fá áburð við gróðursetningu. Ennfremur má benda á að plöntur sem fengu áburð við gróðursetningu voru gildari en hinar og eru því líklegri til að standast betur rótanag rana-



7. mynd. Meðalþvermál grenis og birkis við mismunandi tímasetningu áburðargjafar á Markarfljótsaurum og í Kollabæ frá gróðursetningu vorið 1998 fram til ágúst 2000. Mælingar voru gerðar að hausti. Þvermál var ekki mælt á greni á Markarfljótsaurum árið 1999. Lóðréttar línur sýna 95% vikmörk.

bjallna, en afföll sökum þess geta verið gríðarleg (Guðmundur Halldórsson 1994). Plöntur sem fá áburð við gróðursetningu vaxa betur og eru hærri og gildari en plöntur sem fá áburð síðar. Tilraunin sýnir bersýnilega að betra er að bera á birkiplöntur, hvort sem það er gert við gróðursetningu, um mitt sumar, síðsumars, eða ári eftir gróðursetningu, heldur en að sleppa áburðargjöf alveg (8. mynd a og b).

8. mynd. Birkiplöntur á Markarfljótsaurum eftir tvö vaxtarsumur: a) viðmiðunarplanta og b) planta sem fékk áburð við gróðursetningu. Sveppirnir sem vaxa við hlið plönturnar eru sambýlissveppir / svepprætur af tegundinni *Laccaria laccata*.



Er mismunur í svörun milli trjátegunda?

Sökum mikilla affalla á stafafuru og mislukkaðrar tilraunar á Végeirsstöðum er aðeins hægt að svara þessari spurningu fyrir sitkagreni og birki. Birki gefur mun betri svörun en sitkagreni og gæti það skýrst af eðlislægum mun á tegundum, þ.e. birki er frumherjategund og vex vel í æsku þegar ljós og næring eru ekki takmarkandi þáttur, en greni er hástigsplanta og vex hægt í æsku og hámarkar vöxt sinn síðar í lotunni.

ÞAKKARORÐ

Verkefnið er hluti af stærra verkefni „Áhrif áburðargjafa á líf og vöxt trjáplantna“ sem styrkt er af Tæknisjóði Rannís, Framleiðnisjóði landbúnaðarins og Norrænu ráðherranefndinni (Samstarfsnefnd um norrænar skógræktarrannsóknir). Áburðarverksmiðjan hf. veitti fjárstyrk til verkefnisins. Ingvar Helgason hf. hefur lánað bifreið til afnota fyrir verkefnið yfir sumarmánuðina. Landeigendur á Búlandi, Miðhjáleigu og Voðmúlastöðum í Landeyjum lána land sitt til tilraunanna, ásamt Háskólanum á Akureyri sem léði land á Végeirsstöðum. Fjölmargir aðrir, s.s. starfsmenn Skógræktar ríkisins og Rannsóknastöðvar Skógræktar á Mógilsá, hafa komið að framkvæmd og úttektum á tilraununum. Guðmundur Halldórsson og Aðalsteinn Sigurgeirsson lásu handritið yfir. Eru öllum þessum aðilum færðar bestu þakkir fyrir aðstoðina.

SUMMARY

In 1998 a trial was established, where the effect of different timing of fertilizer application was tested. The aim of the trial was to answer the following questions.

1) Which timing of fertilizer application gives the best survival and growth;

   a) fertilization at time of planting (in June),
   b) in the middle of July,
   c) late August or,
   d) one year after planting?

2) Do the four tree species; downy birch *(Betula pubescens*

Ehrh.), Sitka spruce *(Picea sitchensis* (Bong.) Carr.), Russian larch *(Larix sukaczewii* Dylis.) and lodgepole pine (*Pinus contorta* Dougl. Ex. Loud.), show different responses to the timing of application?

The trial was established on three locations in June 1998, two in S-Iceland and one in N-Iceland. Due to high mortality in pine and problems with waterlogged soils on the site in northern Iceland, only the results from birch and spruce at Markarfljótsaurar and Kollabær were used.

There was no statistical significant difference between treatments, i.e. timing of application, as regards the survival of seedlings. Seedlings that received fertilizer at time of planting were taller, had greater diameter and had greater annual shoot elongation than those receiving fertilizer at other times. The difference was particularly with birch but less pronounced with spruce. Results for birch show that no fertilization at all gives poorer growth and diameter than any of the other treatments that were tested in the trial. Birch gave larger growth response than spruce, which partly may be explained by a generally poorer response of slow-growing species to fertilizer addition.

Allar ljósmyndir teknar af höfundi

HEIMILDIR

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SKÓGRÆKT HANDAN SKÓGARMARKA NSSE

Ágæti lesandi

Með þessu Skógræktarriti er brotið blað í sögu ritsins. Meirihluti þess er lagður undir greinar frá ráðstefnunni *Skógrækt handan skógarmarka* sem haldin var á Akureyri 27.-30. júní 2000. Samhliða þeirri ráðstefnu var haldinn fundur NSSE *(Nordic Subalpine-Subarctic Ecology group),* sem er norrænn sérfræðingahópur um vistfræði birkiskógabeltisins. Til samans sóttu ráðstefnuna yfir 80 sérfræðingar frá 16 löndum og var þetta því stærsta vísindalega ráðstefna á sviði skógræktar sem haldin hefur verið hérlendis. Ólíkt flestum ráðstefnum var þemað ekki bundið við sérstakt fagsvið heldur sérstakan heimshluta, þ.e. lönd við Norður-Atlantshaf utan þeirra svæða þar sem skógrækt og skógarnytjar eru stór atvinnugrein. Þess vegna er hér að finna greinar sem fjalla um mjög mismunandi þætti skóga og skógræktar, allt frá lífeðlisfræði trjáa til félagsfræði skógarnytja. Þar sem þetta er rit alþjóðlegrar ráðstefnu eru greinarnar á ensku, en hverri grein fylgir samantekt á íslensku. Það er von okkar að íslenskt skógræktarfólk finni í þessum greinum ýmsan nytsamlegan fróðleik því hér kemur margt fram sem snertir skógrækt á Íslandi.

Ráðstefnuhaldarar voru Skógrækt ríkisins, Møre rannsóknastofnunin í Volda í Noregi, Skógrøkt landsins í Færeyjum, Stofnun Vilhjálms Stefánssonar og Háskólinn á Akureyri en fyrir NSSE fundinum stóð Akureyrarsetur Náttúrufræðistofnunar Íslands. Styrktaraðilar voru: Nordic Arctic Research Program (NARP), sem heyrir undir Norræna ráðherraráðið, Búnaðarbanki Íslands, Akureyrarbær og Landbúnaðarráðuneytið.

Dear reader

This issue of Skógræktarritið, published by the Icelandic Forestry Association and the main forestry publication in Iceland, includes the proceedings of the *Forestry Beyond the Timberline* workshop and the meeting of NSSE *(Nordic Subalpine-Subarctic Ecology group),* which were held concurrently in Akureyri, June 27th-30th, 2000. Over 80 experts from 16 countries attended the conference, making it the largest scientific conference in forestry held in Iceland to date. Unlike most conferences, the theme was not limited to a specific discipline but rather connected to a specific part of the world, i.e. the North Atlantic region outside the area where forestry is a major commercial venture. Because of this, the papers span a wide range of forestry topics, from the ecophysiology of trees to the sociology of forest utilisation.

The FBT workshop was organised by the Iceland Forest Service, Møre Research, Volda, Norway, the Forestry Service of the Faroe Islands, the Stefansson Arctic Institute and the University of Akureyri. The NSSE meeting was organised by the Icelandic Institute of Natural History, Akureyri Division. Both meetings were supported by the Nordic Arctic Research Program (NARP) of the Nordic Council of Ministers, the town of Akureyri and the Ministry of Agriculture, and FBT was supported by the Agricultural Bank of Iceland.

Þröstur Eysteinsson and Soffía Arnþórsdóttir, editors

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ALEXANDER ROBERTSON

Planting trees on the Avalon Peninsula

SAMANTEKT
Óheft skógarhögg sem leiddi til útrýmingar strandskóganna á Avalonskaga (suðausturodda Nýfundnalands) hófst með landnámi Evrópubúa á öndverðri 17. öld og varaði fram á 20. öld. Útkoman er sú að stór landsvæði sem áður voru skógi vaxin eru nú lyngheiðar eða í besta falli elriflákar. Höfundur fékk það verkefni að gera áætlun um endurheimt skóga á Avalonskaga. Við það var stuðst við reynslu frá gróðursettum reitum af innlendum og útlendum tegundum og kom þá strax í ljós að innfluttar tegundir eins og sitkagreni, rauðgreni og japanslerki stæðu innlendu tegundunum balsamþin, hvítgreni, svartgreni og mýralerki framar hvað varðar vaxtarhraða og möguleika til viðarnytja.

Á Avalonskaga er svalt hafrænt loftslag og mjög vindasamt og bera skógar þess merki. Fyrir utan vindskaða og skafrenning eru skemmdir af völdum frostrigningar algengastar. Við val á álitlegum stöðum til að hefja skógrækt og trjátegundum er mikilvægt að taka bæði tillit til vindálags og jarðvegsgerðar en hvort tveggja hefur áhrif á lifun ungplantna og langlífi skógarins.

Við nýskógrækt á skóglausu landi við erfiðar aðstæður er mikilvægt að breyta svolítið út frá þeim aðferðum sem gilda við venjulega endurnýjun skóga. Við val á efnivið ber t.d. að nota ekki eingöngu fræ af stærstu og bestu trjánum í skóginum heldur blöndu af mismunandi svipgerðum. Hæstu trén í skjólsælum skógi eru ekki endilega þau bestu á berangri. Reynslan á Avalonskaga er að stórar og öflugar berrótarplöntur lifa betur en bakkaplöntur. Við gróðursetningu er gott að velja set í skjóli, t.d. við stein eða þúfu en ekki ofan á þúfum. Þá er mikilvægt að þekkja aðstæður og vita hvaða vindátt er verst.

Mikilvægast er að rækta skjólskóga, t.d. með því að gróðursetja hraðvaxta víði eða lerki ýmist sem skjólbelti eða skerm til að skapa skjól fyrir aðaltegund skógarins, sem gæti t.d. verið greni. Til að brjóta upp vindinn er mikilvægt að skjólbelti og skógarjaðrar myndi hrjúft yfirborð, en það fæst með því að blanda saman tegundum sem eru misjafnar að stærð og lögun, tré og runna, lauftré og barrtré, hávaxin og lágvaxin. Áhersla er lögð á að skógræktarfólk getur lært ýmislegt frá garðyrkjunni hvað þetta varðar.

Introduction
The indiscriminate cutting that led to the deterioration and, in some cases, denudation of-coastal forests on the Avalon began with the early European settlers. As far back as 1623, Richard Whitbourne complained:

> *For it is most certain our Nation, upon their arrival yeerly to that countrey, doe cut downe the best trees they can finde, to build their cottages and roomes withall, for their necessary occasions; herring , rinding, destroying many others, that grow within a mile of the sea, where they used to fish."*

This situation prevailed well into the 20th century. Indeed, from 1901 to 1920, there was a special provision in legislative acts respecting forests on Crown lands, that no timber licenses be issued within 3 miles (48 km) of the coast to reserve timber and fuelwood exclusively for the fishing communities. In practice, exploitation of coastal timbers extended inland well beyond 3 miles In addition, there is a long history of wildfires A few from lightning strikes, but most set by people. In fact, fires set by people was such a problem during Early European settlement, that in 1610, Sir John Guy enacted a law whereby it was an offence, punishable by a £l0 fine (an enormous sum in those days) for anyone to set a fire in the woods. Sir Richard Whitbourne made a similar proclamation in 1767.

The result is that large coastal tracts of denuded forests have been converted to heath and at best alder thickets. But, because of the moist climate, extensive tracts have been naturally regenerated by a dense, almost impenetrable forest of balsam fir and black spruce, and lesser amounts of other native tree species (tamarack, birch, dogberry and pin cherry)

It is fair to say that even longtime residents assume that low coastal barrens and somewhat low stature forests are natural ecosystems. In truth, they are a poor reflection of the true potential of the coastal forest that prevailed in the 16th and early 17th century period of European settlement. One only has to look at the dimensions of logs in photos of late 19th and early 20th century logging operations in north central Newfoundland to see just how much more productive pre-settlement forests were.

With respect to restoration and refurbishing coastal forest on the Avalon Peninsula two principle questions come to mind: can man-made barrens be restored to forests: if so, what is the true potential yield of forest productivity.

Both questions have been positively addressed by Lt-Col. Jack Turner CBE, MC. Turner was appointed Newfoundland's first Chief Forester in 1934. His first priority was to refurbish the man-made barrens and scrub lands back to productive forest. To that end, Turners all-encompassing forest management plans made provisions for a large and sustained plantation program to reforest denuded areas on the Avalon Peninsula. By 1948 about six hectares were under cultivation at the National Tree Nursery. During the l0-year period between 1938-48, the National Tree Nursery produced approximately seven million seedlingsincluding 1.1 million seedlings freely distributed to schools, interested groups and individuals. Most of the stock was planted within the so-called Three Mile Limit along the coastal fringe where forests were indiscriminately cut and also on barrens on the Avalon and Bonavista Peninsulas. Early forestry reports and a somewhat prevailing view, maintain that pine plantations established between 1938-52 on the denuded areas within the Three-Mile-Limit are failures - especially now that the pine plantations are suffering from wind-throw. However, as this report shows, in terms of wood volume, these plantations have outperformed neighbouring fir and spruce forests of the same age (and alder) by a factor of at least 2:1. Also, individual trees in a small group of Norway spruce trees planted about 50 years ago near Salmonier National Tree Nursery is 10-20 times the average volume of individual native trees in typical forests on the Avalon. Even more remarkable, is the phenomenal growth Sitka spruce in three small plots on the exposed coastal barren in Trepassey on the southern tip of the Avalon Peninsula. At 47 years of age, their average height is 14 m, average DBH is 35 cm (SE± 1.4) and individual tree volume 0.14-1.1 m^3. Also, a few Sitka spruce have naturally regenerated in the alder thickets. One 7 year-old sitka spruce sapling is approximately 3 m tall.

No major planting has been done on the denuded areas of the coastal fringe of the Avalon Peninsula since 1952. Nevertheless, since the 1960's, many small experimental plantations have been established throughout the Avalon Peninsula. The annual planting program by the Boy Scouts of Canada is a notable contribution The Scouts plantations are valuable in terms of the knowledge gained on the performance of Japanese, European and Hybrid larches and spruce in many different contexts such as urban areas, on barrens, in forests, on good sites and bad, etc. In fact, the Scouts have probably planted in more nooks and crannies and on a broader range of sites than any other organization - government agencies included.

There is a much longer tradition of tree planting within towns and villages. The oldest living planted trees in the province are European beech dating back to the 1840's. And whereas foresters have tended to limit planting to 2- 3 species of trees (mainly black spruce and Japanese larch), more than 200 hundred species, varieties and forms of trees have been planted in towns and villages - with new varieties added every year. On the whole, exotic species - elm, oak, beech, ash, poplar, Douglas fir, pine and spruce - are taller and produce more volume per tree than native species cultivated alongside them. Of course, one would think that urban trees do better because they are lavished with due care and attention. This is true in older part of towns and cities. But since the 1950's, the usual practice of developing large subdivisions and shopping centres, is to strip the land bare of trees and topsoil. When building is complete, the 'garden' area is back filled with coarse gravel and covered with 2-5 cm of poor topsoil. The result is a soil substrate that is vastly inferior to any soil a forester would think of planting in. Even so, residents, most with little knowledge of trees, have achieved good results on these urban deserts.

With regards to the selection of tree species and expectations of growth and yield, the common thread between plantation foresters and gardeners is that they base their chances of tree planting success primarily on their own and others trial and error experiences. On familiar territory, foresters have a considerable advantage in having training and experience in determining the forest potential of prospective planting sites. But in new territory, especially in areas with a harsh climate and where there is little experience with tree planting, foresters have little more to draw upon than their intuition. This situation has confronted the author over the years that he has tackled tree planting. mostly with great success, so much so that he was asked to explain and give recommendations on how he would proceed to reforest the man-made barrens on the Avalon Peninsula. The author's basic tricks of the trade, many of them quite unorthodox, are described in a CD and 262 page book *Planting Trees on the Avalon Peninsula,* containing roughly 600 photographs and illustrations. The following is a synopsis of that publication.

PART I: PLANTATIONS

This section describes the results of some of the plantations established by the Government of Newfoundland between 1938-52 in Conception Bay North, Tilton, Marysvale, and small plantations established between 1970-1990 by various government, volunteer and private citizens organizations. Environmental influences affecting tree growth and regeneration in plantations are also described.

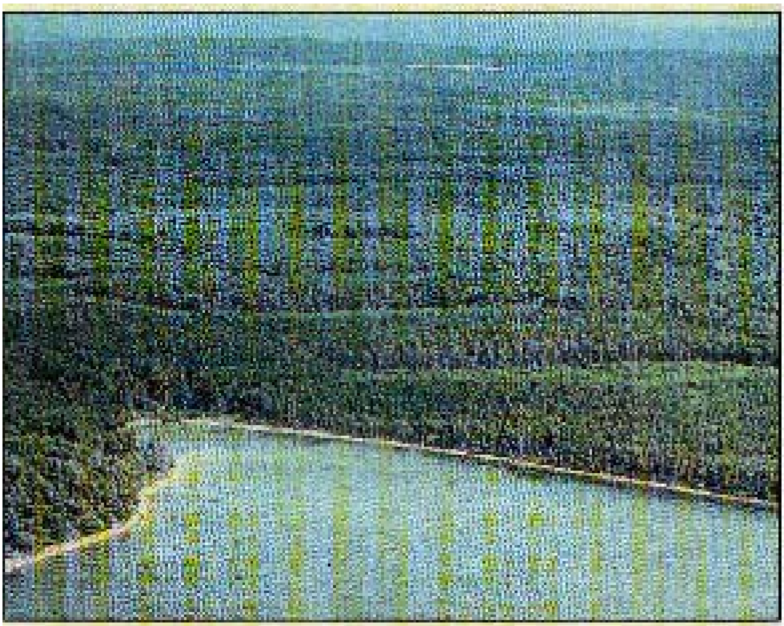
The Avalon has an insular climate, best described as Cool-Temperate or Oceanic Boreal. General climate statistics are based mainly on one station at St. Johns Airport, which does not give much useful data about how climate and weather affect tree growth.

A better approach is to express the relationship between forests and atmosphere in terms of the energy cascade. In the late 1980's early 1990's energy fluxes were measured on planting sites at Glenwood in central Newfoundland, in the experimental nursery at Pasadena and a clearcut near St. Georges in western Newfoundland. The energy flux measurement technology was transferred to Gunnarsholt, south Iceland where its capabilities were expanded and it is now part of the extensive EUROFLUX network. While measurements of energy fluxes do not give a direct assessment of potential plant growth per se, they do, nevertheless, give foresters an insight of how daily fluctuations of such variables as solar radiation, evapotranspiration and soil heat flux influence tree growth on cold and warm days, respectively. Given that the Avalon has a cool-temperate climate, its energy cascade is capable of supporting much more highly productive forests than currently exist. This conclusion is reinforced by the fact that, even on barren sites, plantations have generally far outgrown local natural 'forests' by a factor of as much as 20:1.

PART 2: PHYSICAL ENVIRONMENT

Wind is the most limiting factor reducing survival and growth of both natural woodlands and plantations alike. Wind flows in very organized patterns. From a silvicultural standpoint, coming to grips with the pervasive wind is a seemingly impossible task. It is especially difficult to visualize what patterns wind will create far into the life of a plantation. The best insight by far is to study the short-term and long-term impact of wind on plantations, forest and individual trees. For example, clues as to the prevailing patterns of wind can be inferred from patterns of tree growth on the shores of sea coasts, lakes, broad rivers and even across

Fig. 1. Spirity Cove wave forest shows the effects of helical roll vortices. *Ölduskógur sýnir áhrif lágréttra skrúfvinda.*



grassy fields. If foresters learn to the *read* the wind´s signatures it will give an enormous boost to their skills in ecosystems management and plantation design. Among the most obvious signatures of surface wind patterns are wind-shaped forests, the most striking of which are the wave forest and wave tuckamore phenomena.

The relationship between wind and soil type are inextricably linked to forest longevity and stability. The report describes the principal types of soils suitable for plantation forestry and how they affect root growth and ultimately forest stability

Persistent and often strong wind, heavy loading by freezing rain and desiccation resulting from the blasting of foliage by airborne ice-crystals, affects the productivity of forests on the Avalon Peninsula. Also, the dynamics of very short-lived events, like a few hours of severe freezing rain, gales, fire and even a solitary bark beetle can be the catalyst for major structural changes across a forested landscape. Similarly, small changes in planting practices, such as improper storage and shipment of seedlings, or a tree-planter feeling poorly after a late night out, can have major deleterious long-term effects on the plantation. Dynamically speaking the fundamental processes that triggers change and thus creates new patterns and levels of biodiversity is called chaos or, in the context of forestry, spatiotemporal chaos. In the context of tree planting spatiotemporal chaos comes on to play in the design of plantations for harsh environments, where there is an inordinate number of environmental and human influences leading to success or failure. In a nutshell the dynamical approach to plantation forestry is to throw away all the normal conventions of regularity and design into plantations the same roughness elements that natural forests have developed as an adaptation to a windy climate.

PART 3: TREES AS BIOLOGICAL INDICATORS OF WIND

This section is intended to fine-tune the foresters intuitive senses that will enable them to better 'read' the dominant signatures of the principal atmospheric and soil influences on tree-growth. Learning to read signatures of complex physical phenomena in the landscape pays dividends in terms of improving forest productivity and increasing the longevity and stability of forests and plantations.

Virtually every event in a forest has a directional component. Of all the directional influences on a forest, wind perhaps is the most obvious insofar as it shapes trees and changes patterns of forests. To some extent, wind is controllable. But in order to exert even a modicum of control over the wind, foresters must learn to map its patterns, severity, and direction. Related to wind exposure is perhaps the more important aspect of tree deformation caused by freezing rain and windborne ice crystals from the snow pack. Knowing the severity of freezing rain determines what tree species should be planted. Wind-borne ice crystals deform saplings. Although trees will eventually grow above the snowblasting layer, the long-term effect is subdued growth. Therefore, on windy sites, it is important to factor snow-blasting into design of a plantation. There are many directional phenomena that control forest growth and patterns. Among the obvious ones are wind throw, and crown deformation by persistent winds. However, response of forests and plantations to winds from different directions is not always immediately clear. For example, in some of the plantations, westerly winds caused crown deformation, whereas strong northeasterly winds caused endemic (sporadic) wind throw of isolated trees, while gale-force northerlys caused wind throw of large patches.

Part 3 also introduces circular statistics - another relatively new paradigm - which enables foresters to sort out direction of atmospheric properties that affect natural regeneration and stand structure. This will enable them to design more productive and wind-firm plantations.

Circular statistics provide the basic tools, by example, for foresters who wish to quantify directional phenomena such as tree deformation, orientation of wind throw, even the extent of compression wood in boles and correlated these with atmospheric properties. These tools are indispensable for plantation orientation, exposure rating, seed tree location, predicting spread of natural regeneration and of fire, blow-downs, etc.

PART 4: SEED COLLECTING

Native trees adapt to environmental influences. The typical practice of seed collection is to choose the dominant and/or the best formed trees. This works well enough if the seeds are raised to seedlings destined for plantations in relatively benign sites. But for the early stages in reforesting denuded areas, it is advisable to be more concerned with hardiness, than height and form.

A brief discussion on the merits of collecting seed from a broader range of phenotypes is

Fig.2. An example of shelterwood. Compare the growth of spruce on the right (in shelter) with a traditional plantation without shelter on the left *Dæmi um skjólskógrækt. Berið saman vöxt grenisins nægra megin (í skjóli) og hefðbundna skjóllausa gróðursetningu vinstramegin.*

discussed. This part also includes illustrations of various cones, catkins and husks of tree species, as well as routines for collecting, storing, extracting and processing. It is intended for the public who may have an interest in growing their own trees and forestry students and technicians who may not have much experience in collecting and processing seeds.

PART 5: TREE NURSERY

It is the authors opinion that anyone entrusted with an expensive tree-planting program ought to have at least a couple of years of experience in nursery practice. The basic knowledge and experience of what it takes to make seedlings grow well, is a valuable asset for creating successful plantations in harsh environments. Except for matters related to production costs, the merits of container seedlings vs. bare root seedlings for general purpose planting are still unresolved. The authors experience clearly indicates the superiority of bare-root stock for planting on barrens and on atrocious urban sites. The main reasons are that bare-root stock has a larger stem and root mass. Bare-root stock also contains considerably more in situ nutrient reserves in the soil attached to root-ball and within the seedling. This enables bare-root stock to survive, adapt and grow more quickly on harsh sites than seedlings grown in small containerised plugs. The technical reasons for the difference in performance are explained.

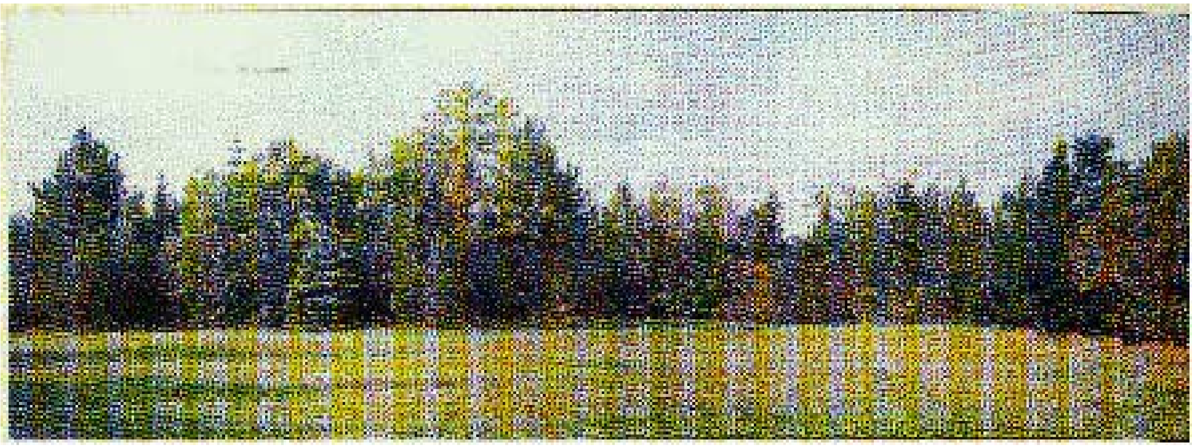
PART 6: TREE PLANTING

The standard tree planting specifications are well-crafted and should be adhered to when planting relatively benign sites. However, in the first stages, or at least on the leading edge of plantations on exposed sites some minor modifications to the standard specifications need to be adopted. The principal goal is to break up strong laminar flow of surface winds into beneficial turbulence. This can be achieved by creating rough leading edges and avoiding planting in straight rows which can channel wind and create strong jets that permanently diminish growth potential.

This gives a brief overview of planting practices in accordance with standard specifications developed by the Department of Forest Resources and Agrifoods. However, there are minor points in the standard specification used by DFRA that need adjustment for planting on exposed sites on windy barrens.

PART 7: SHELTERWOOD SILVICULTURE

Forest management on the Avalon Peninsula is geared much more to multiple-use than elsewhere in the Province. The multiple use strategy is made all the more complex by the fact that the best plantable denuded scrubland lies within the jurisdiction of municipalities. The uncertainty of urban development over the long term tends to dampen enthusi-



asm for plantation forestry. However, the need for plantation forestry within municipal areas, under synonyms such as urban forestry, environmental forestry, sustainable forestry and multiple use, is self-evident. There is the need to protect watersheds, natural habitats, aesthetic landscapes as well as provide recreational areas, fuel wood, timber - all of which generate employment directly and indirectly. There are many traditional, quasi-commercial silvicultural systems that have been practised with success for centuries in densely populated countries. Principal among them is shelterwood silviculture which may be well suited to plantation forestry within municipal boundaries.

Shelterwood silviculture describes unobtrusive silvicultural systems that can produce a virtually perpetual source of wood while preserving the integrity of the forest landscape. From a purely productive standpoint, the main advantage of shelterwood systems is that they are a good foundation upon which to establish a long-term program to refurbish forests in denuded areas.

PART 8: CULTIVATED TREES

There is, unfortunately, a dichotomy between forestry and arboriculture. In the context of tree planting the dichotomy is artificial because the skills required for one specialty are complimentary to the other. One need not look any further than the wide-range planting habits of the Boy Scouts of Canada. The Scouts make no distinction as to whether their tree planting is in a forestry or arboricultural context. A more salient reason for closely linking Forestry and arboriculture has to do with the fact that:

a) forestry concentrates on a very small number of tree species usually for one purpose in mind; whereas b) arboriculture is much more eclectic in its choice and use of not only broad range of tree species but also an even wider range of shrubs.

This provides an insight into the broad range of tree species cultivated on the Avalon Peninsula and how they fit into the urban landscape. What is more important, the potential of certain species and how they are mixed in a landscaping context can be adapted to plantation forestry, for energy conservation, environmental protection and aesthetics in the context shelterwood silviculture as part of an overall municipal forest management plan.

Fig. 3. Roughness is important. *Hrjúfleiki* er *mikilvægur.*

SIGURÐUR BLÖNDAL

Development of forestry in Iceland during the 20th century

SAMANTEKT
Í greininni er fjallað í stuttu máli um helstu atriði í sögu skógræktar á Íslandi, einkum síðan 1950. Fjallað er um innflutning trjátegunda, uppbyggingu gróðrarstöðva á sjötta áratug síðustu aldar, samdrátt í kjölfar aprílhretsins 1963 og dauða skógarfurunnar, uppbyggingu rannsókna og aukningu í skógrækt á ný um og eftir 1990 með tilkomu landshlutabundinna skógræktarverkefna og Landgræðsluskóga. Þá er fjallað um helstu trjátegundir sem gróðursettar eru á Íslandi.

History

The year 1950 was a turning point in Icelandic forestry. Since 1910, emphasis had been on the state, through the Iceland Forest Service, obtaining, enclosing and protecting the best remnants of birchwoods, many of which are now our most cherished national forests. After 1950, plantation forestry based mostly on exotics, became more important in terms of effort and capital investment. Contacts made to Alaska, northern Scandinavia, the USSR and regions with high elevation forests at more southern latitudes, such as the Colorado, led to importation of seed for experiments with tree species that were likely to survive in Iceland.

Tree nurseries were built to meet the need for seedlings and production exceeded 1 million seedlings by 1958. At that time, there were two actors in forestry: the Iceland Forest Service and forestry societies. The former concentrated on managing birchwoods and planting exotics within them, the later on afforestation of treeless land. In 1960, there were over 8,000 members of forestry societies out of a population of 177,000.

Two setbacks in the early 1960's had very negative practical and psychological effects on the development of forestry. These were the failure of Norwegian Scots pine, the most-planted species during the 1950's, and an unusually long winter warm spell followed by hard frosts in April, 1963 causing massive tree mortality in southern and western Iceland, especially among the Alaskan species. The practical outcome was to search for new species and provenances, but the psychological effects were a much more difficult challenge, with planting not reaching 1960 levels again until 1990.

The need for forest research was better recognised and a substantial gift from the Norwegian people allowed a research station to be opened in 1967. In 1969, parliament first approved funding for grants for establishing woodlots on farms. This was a pilot project on only a few farms in Eastern Iceland. These two developments, along with experience gained in the national forests, are the foundations of Icelandic forestry today.

Increased funding for forestry during the 1970's led to several technical developments, including advances in nursery production. A sharpening of afforestation goals took place at this time as well in connection with the Land Reclamation Plan in 1974. Farm afforestation was expanded by a 1984 act of parliament, with the goal of establishing timber production plantations in those areas where it was considered feasible. This in turn led to the establishment a regional farm afforestation project in East Iceland in 1991, followed by other similar regional projects in other parts of the country. By 2000, such regional projects covered the whole country, providing grants to land-owners for afforestation with multiple-use goals, not necessarily including timber production.

The Land Reclamation Forest Project was initiated in 1990 by the Icelandic Forestry Association, whereby 1 million seedlings have been planted every year since, mostly by forestry societies in co-operation with local municipalities. State funding for afforestation has increased dramatically during the last decade, the main rationale being rural development aid and carbon sequestration. Because of this, planting has increased to about 5 million seedlings annually and is set to continue to increase during the next decade.

At the same time, increased consideration of environmental issues has led to changes in both afforestation planning and implementation. Exotics are no longer planted into birchwoods, wetlands are not drained for forestry, species mixtures are now planted instead of monocultures and in 1999, the native downy birch was the most planted tree species in Iceland for the first time since 1951

The major tree species used in Iceland

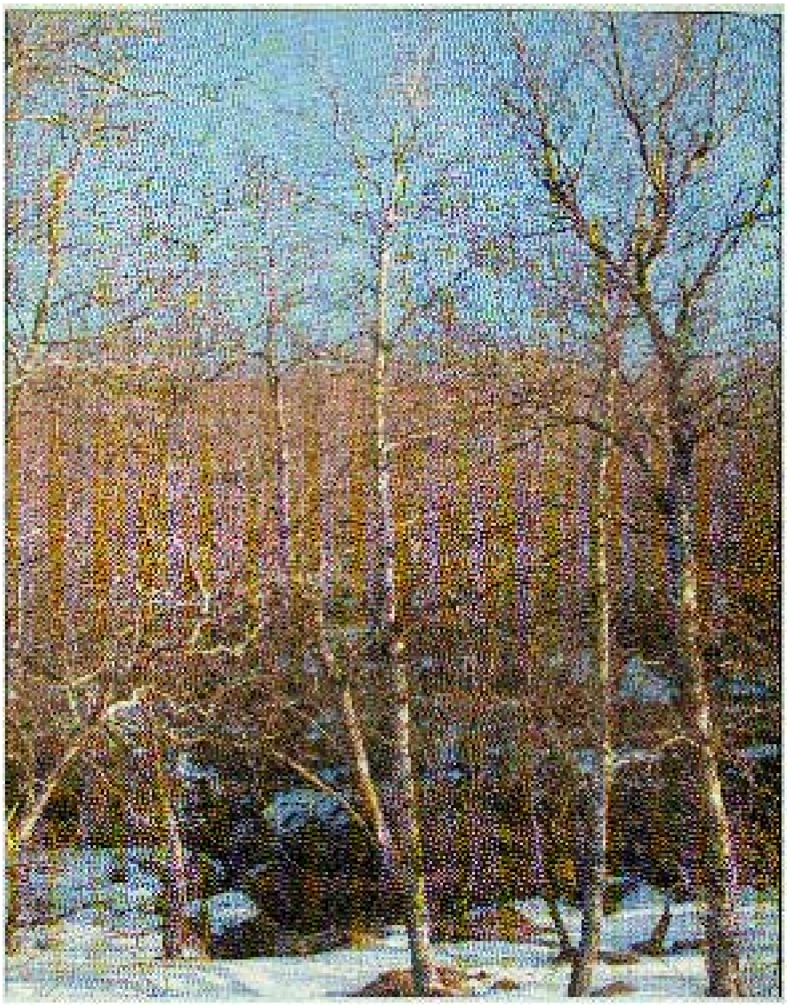
Downy birch *(Betula pubescens* Ehrh.) and its hybrid complex with *Betula nana* (L.)

This is the only native species that forms continuous forests or woodland. The total area of birchwoods is about 120,000 ha, of which 20,000 ha are birch forests taller than 5 m, reaching a maximum height of 12- 13m, and 100,000 ha are scrub. This amounts to about 1.2% of the land area of Iceland, compared to an estimated 25-30% (basically the entire lowland area) forest and woodland cover at the time of settlement in the late 9th century AD.

Most of the birch scrub is a hybrid complex between *Betula pubescens* and B. *nana.* Most of the birch in S- and W-Iceland is very low-growing, whereas true forests can be found in N- and E-Iceland.

The birch woodlands were an essential resource to the Icelandic people for 1000 years; being utilised for fuel, charcoal (for iron smelting and tool making), building material and fodder for cattle and sheep. The demise of forests was the main cause of both general poverty and the incredible soil erosion that has taken place.

The birchwoods are no longer economically important but their perceived importance as habitat, for soil protection and for recreation and landscape is increasing. Planting of native birch has been increasing in recent years, comprising 37% of the total planted in 1999 or 1.2 million seedlings. A total of 14.7 million downy birch seedlings were planted in Iceland between 1945 and 1998, making it the second most planted species, after larch. Efforts are under way to improve native birch through selection and breeding.



Icelandic downy birch at Hallormsstaður. Height 11-12 m.
(Photo: T. Eysteinsson)

Russian *(Larix sukaczewii* Dylis) and Siberian larch (L. *sibirica* Ledeb.)

Taxonomists disagree as to whether these are one or two species. Their distinction is however useful for Icelandic forestry. Siberian larch from southern Siberia and the Altai mountains was most planted earlier, but

Russian larch originating from the Archangel district, which is better adapted to Icelandic conditions, has been used almost exclusively during the last 20 years.

Larch was first planted in Iceland around 1900 and the first true Russian larch stands were planted in the late 1930's. Their mean annual increment at age 60 is 7 m^3/ha/yr and the maximum height is 21 m.

Larch survives and grows best on rather poor heathland and eroded sites: making it ideal for reclaiming degraded grazing land. Its mycorrhizal associate, the larch bolete *(Suillus grevillie)*, follows it wherever it is planted and is in fact essential for survival and growth. Because larch lets a large amount of light through to the ground, rich understory vegetation usually develops under a larch canopy, even when larch is used to reclaim gravel mines.

Russian larch achieves good form and is usable for timber production only in interior valleys in N- and E-Iceland. However, it is an excellent nurse species for spruces and even lodgepole pine and planting of such mixtures is increasing.

Several fungal pests have attacked Siberian larch and Russian larch in Iceland, with larch canker *(Lachnellula wilkomii)* and/or conifer canker *(Phacidium coniferarum)* limiting its usefulness in the more maritime regions of S- and W-Iceland. Selection and breeding for improved adaptation is under way and production of putatively improved seed in a greenhouse seed orchard has commenced.

Russian larch, mostly originating from Finnish seed orchards, has been the most planted tree species in Iceland during the last decade, and from 1945-1998, 16 million seedlings of Russian and Siberian larch were planted

Natural regeneration has been noted in many places

Sitka spruce *(Picea sitchensis* (Bong.) Carr.)

Sitka spruce was first planted in Iceland in 1937, with the first large seed lots arriving from Alaska in 1941. It was extensively planted during the 1950's and early 60's but interest in it diminished after much of it was severely damaged in 1963. Planting has increased again since 1990 and it is now the second most planted exotic species, comprising 19% of trees planted in 1999. About 10 million Sitka spruce were planted in Iceland from 1945 to 1998, putting it in 4th place among species planted.

After a long establishment phase, sometimes taking 20-30 years to reach breast height, Sitka spruce outgrows all other conifers. Mean annual increment at age 35-48 is 5-9 m^3/ha/yr with current annual increment 16-26 m^3/ha/yr and dominant height 8- 14 m. The tallest Sitka spruce in Iceland is 20 m at age 45. Sitka spruce will be the main timber producing species in Iceland. It is also the most wind resistant spruce species and can be grown on sites degraded by grazing.

The only serious pest that attacks Sitka spruce in Iceland is the green spruce aphid *(Elatobium abietinum)*, with severe defoliation often occurring after mild winters. Sitka spruce is rarely killed by the aphid, but growth is diminished for some years after severe defoliation

Natural regeneration has been noted in several places.

White spruce *(Picea glauca* (Moench) Voss)

White spruce was planted in two places in Iceland around 1900. The origin of the trees was eastern North America and they fared poorly although a few individuals still survive. Several stands of white spruce were planted in the 1950's, the material mostly originating from the Kenai Peninsula in Alaska, but no white spruce was planted from 1970 to the early 90's.

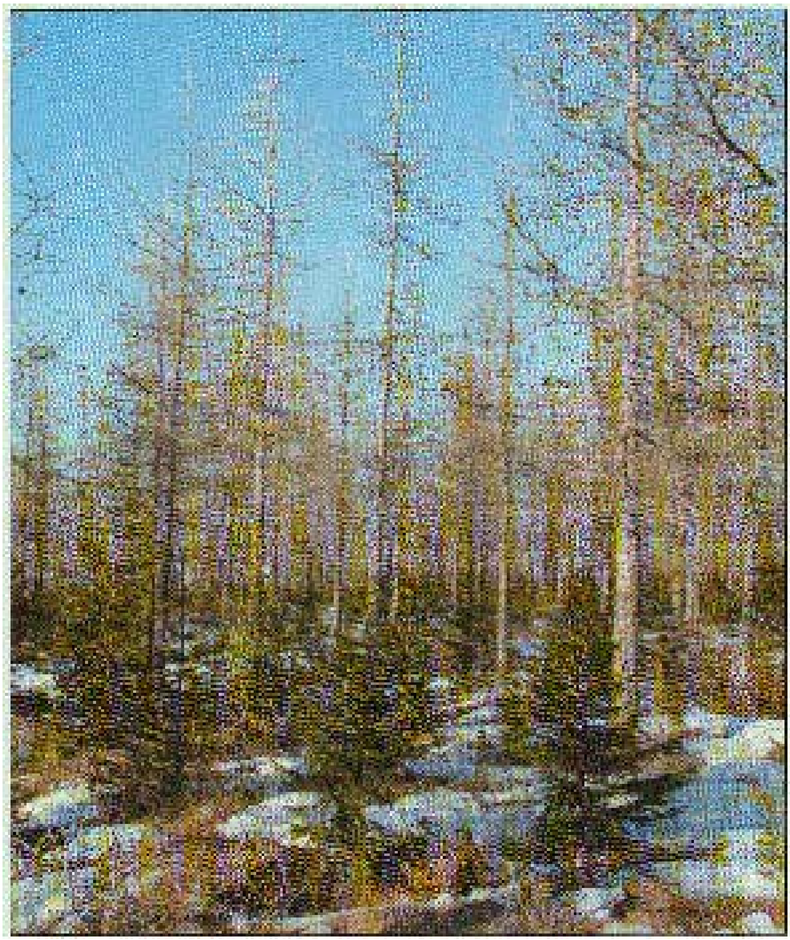
White spruce could be called the “forgotten spruce”. However, stands from the 50's are now growing well and interest in the species is increasing. It has very good form and branching habit and should therefore be of interest as a timber species. At age 34 on a good site, the mean annual increment is 3.8 m^3/ha/yr and dominant height is close to 10m.

Lutz spruce *(Picea x lutzii* Little)

This is the hybrid between Sitka spruce and white spruce that grows naturally in southern Alaska. It was first planted in Iceland in 1958 in a trial of four spruce species. The dominant height is 12 m at age 40. Lutz spruce is intermediate in most respects between its parent species, having higher growth rate than white spruce and better form and finer branches than Sitka spruce.

Norway spruce *(Picea abies* (L.) Karst.)

Norway spruce was first planted in Iceland shortly after 1900 and the tallest of these trees are now 17m. Planting of Norway spruce stands commenced in 1948 and by the late 50's, it was one of the most planted species. Substantial planting continued into the mid 1970's, after which it decreased, the reason being very poor growth on site types generally available for afforestation (heathland) and poor wind tolerance. Norway spruce now comprises only about 1% of trees planted in Iceland annually.



Norway spruce under a Russian larch shelterwood.
(photo: T. Eysteinsson)

On good sites and given good shelter (such as using larch as shelterwood) however, Norway spruce does quite well. Under such conditions, it has reached a height of 13 m at age 40. It has good form and is therefore of interest as a timber species when grown in a mixture with larch. Norway spruce has been the main Christmas tree species grown in Iceland but is gradually being replaced by Engelmann spruce, lodgepole pine and subalpine fir.

Norway spruce is in fifth place among species in total number of seedlings planted, with 4.2 million planted 1945-1998.

Engelmann spruce (*Picea engelmannii* Parry)
Engelmann spruce was first planted in Iceland in 1905 and the tallest of these 5 trees is now 19m. These trees have produced seed off and on and thousands of their offspring are now growing all over Iceland. Most Engelmann spruce planted in Iceland originated in Colorado at elevations of 2,500-3,500 m.a.s.l.

Engelmann spruce can grow quite well on good sites but no true yield measurements have been made. It is mostly of interest as a Christmas tree and for amenity.

The first large seed lot arrived in 1950 and planting has been steady since and increasing recently, although never more than around 100,000 seedlings per year. In 1999, Engelmann spruce comprised about 2% of planted seedlings.

Lodgepole pine *(Pinus contorta* Dougl. var. *contorta* and var. *latifolia Engelm.)*
A few lodgepole pines were planted in the late 1920's and 1930's. They originated in the eastern Rockies of Canada and Washington or Oregon, have grown slowly but are alive and healthy. The oldest stand of lodgepole pine in Iceland was planted in 1940; provenance Smithers British Columbia, 700 m.a.s.l. The mean annual increment in this stand at age 60 is 5.5 m^3/ha/yr and the maximum height is 17 m. These pines have straight boles and narrow crowns (var. *latifolia)*.

The first large seed lot came from Skagway, Alaska in 1954 and planting commenced in 1958. Since then, lodgepole pine has been among the most planted species in Iceland, especially during the 1980's and 90's. Over 10 million seedlings were planted between 1954 and 1998, making lodgepole pine the third most planted species in Iceland. It was fourth in 1999 with a 10% share of seedlings planted

The Skagway provenance is well adapted throughout Iceland and seems to be intermediate in form between var. *contorta* and var. *latifolia.* Lodgepole pine starts bearing cones at an early age and natural regeneration has been noted in several places.

Black cottonwood *(Populus trichocarpa* Torr. & Gray)
The first black cottonwood cuttings came to Iceland in 1944

from the Kenai Peninsula in Alaska and were cultivated in a small nursery in southern Iceland. They had reached 14 m in height by 1963, when their stems were killed by the unusual spring weather (see above). Their root suckers are now 20 m in height. Material was obtained from more southerly and maritime locations in Alaska and that is now mostly used in S- and W-Iceland, while the Kenai material is used in N· and E-Iceland.

Black cottonwood was mostly planted as garden and park trees from the 1950's to 80's, which now form a large part of the urban forests in towns such as Akureyri and Egilsstaðir. Mass propagation and forestry planting did not start until 1987, with planting of 100,000-150,000 saplings annually since then. In 1999, black cottonwood comprised 4% of trees planted.

Black cottonwood planted in gardens and receiving good care can reach 20 m in height in 30 years. A forest stand of the same age yields a mean annual increment of 15 m^3/ha/yr at 1600 stems/ha. Many clonal trials have been planted during the past decade and clonal selection will lead to further improvements.

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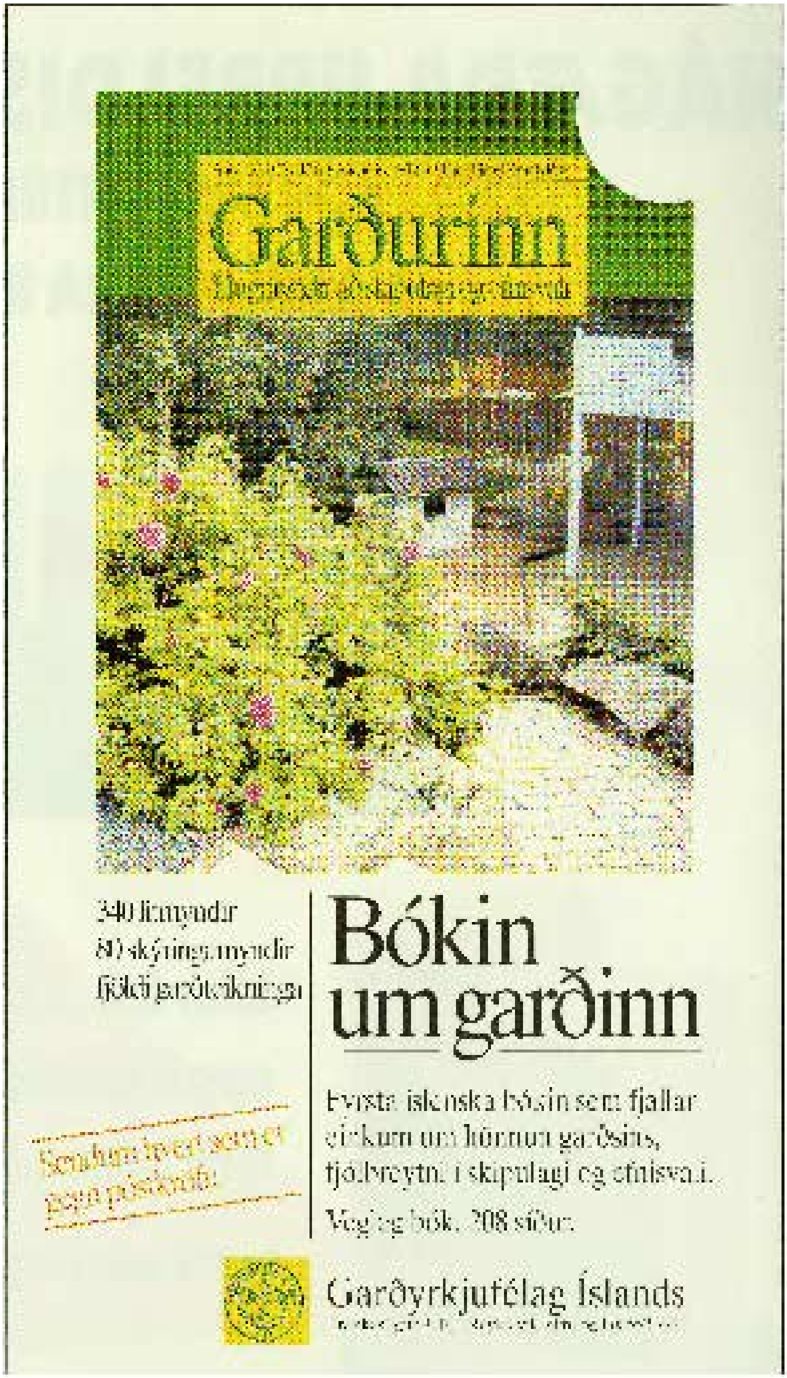


TRÓNDUR LEIVSSON

A short note on tree planting activity in the Faroe Islands

SAMANTEKT
Áhugi á trjárækt í Færeyjum hófst seint á 19. öld en fyrstu skógarreitir voru ekki gróðursettir fyrr en um og eftir fyrri heimsstyrjöld. Meðal vel heppnaðra tegunda eru sitkagreni, silfurreynir, garðahlynur og stafafura, sem nær 7 m^3/ha/ári viðarvexti. Flestir gömlu reitirnir eyðilögðust í fárviðri í desember 1988.

Skógrækt landsins er ríkisstofnun sem sér um skógræktarmál í Færeyjum. Fjárveitingar til hennar voru 2,4 milljónir danskra króna árið 2000 og þar vinna 6 fastráðnir starfsmenn. Meðal verkefna stofnunarinnar eru stjórnun og ráðgjöf, gróðrarstöðvarekstur, trjásöfn og umsjón með skóglendum, þ.á m. útivistarsvæðum.

Gróðrarstöð var stofnuð 1909 og nú eru í framleiðslu um 120 trjáa- og runnategundir og yrki. Innlendar runnategundir eru sömu 4 víðitegundir og vaxa á Íslandi auk einis og rósar. Við landnám óx þó kjarrskógur af ilmbjörk og jafnvel hesliviði á öllu láglendi Færeyja, en þær tegundir eru nú útdauðar. Skógrøkt landsins hefur safnað eintökum af innlendum runnum þar sem leifar þeirra finnast og fjölgað þeim, m.a. til að bjóða fólki upp á ræktun þeirra í görðum.

Skógræktarreitir eru afar vinsælir til útivistar og m.a. nýttir til sveppatínslu. Þá hefur einn bóndi hafið jólatrjárækt og annar hafið landgræðslu með lúpínu.

Background information:
The Faroe Islands are situated between Scotland and Iceland on 62^0 N and 7^0 W. They consist of 18 islands with at total area of 1.400 km^2. The highest peak is 882 m a.s.l. and the average elevation is ≈300 m a.s.l. The islands are of volcanic origin and are made up from some sixty million years old basalt. The soils are generally shallow and rather poor in nutrient status. The lowland, i.e. up to about 200 - 300 m a.s.l., is frequently covered with peat of varying depth.

In Tórshavn, the capital, the mean temperature in August is 11,1 °C and in February 3,7 °C. The average precipitation is 1.450 mm in Tórshavn, but it varies in the range from 850 mm near to 3.000 mm within the islands. Summarized, the climate is windy, rainy and unstable. The main income for this community of about 45.000 inhabitants is fishing and fish industry

The interest in tree planting in the Faroes began towards the end of the nineteenth century, but successful plantations, mainly with conifers, were not established until the time of 1st WW and onwards into the twenties and thirties. Some of the most successful tree species were *Pinus contorta, Picea sitchensis, Sorbus intermedia* and *Acer pseudoplatanus.* A severe gale in December 1988 destroyed most of the old plantations.

Skógrøkt landsins (the Forestry Service):
The tree planting activity and trials financed by the Faroese government are organised within the governmental institution Skógrøkt landsins. Our legislation dates back to 1952.

The total financial framework for this activity in 2000 is as follows:

Governmental funding	DKK 2.000.000
Business dependant income	DKK 400.000
Skógrøkt landsins, total budget	DKK 2.400.000
Additional funding from local communities	DKK 460.000

The permanent workforce at Skógrøkt landsins is 6 persons, plus some external labour. The local communities provide another 3 person workforce per annum in our areas. Our workforce is well skilled, both in the nursery and in the woodland squad.

Tasks at the Skógrøkt landsins include:
- Administration, advice, and various governmental duties.
- Nursery (only trees and shrubs)
- Arboretum unit and dendrological trials.

Fig. 1. In Havnardal.

Fig. 2. In Gundadal.

Fig, **3.** In the garden of J. Dahl.

- Afforestation sites, including recreational areas, ≈80 ha.

Glimpses of developments:
One hundred years ago, the number of suitable species of trees and shrubs available for those citizens who were interested in planting for gardening or other purposes, were limited to around 10- 15 species. In 1909, the first tree nursery in the Faroes was established in the woodland area in Tórshavn. In 1977 the Skógrøkt landsins joined the Nordic Arboretum Committee and thus got access to new plant material of specially suited origin.

In 1991 the Skógrøkt landsins was able to allocate the first resources to work full time with plant production in the designated nursery area. Today's nursery stock list at Skógrøkt landsins comprises a total of 120 different tree and shrub specie, cultivars etc. This material has been under some trials and can now be recommended for use.

The indigenous dendroflora at present consists of: *Salix phylicifolia,* S. *lanata,* S. *arctica,* and S. *herbacea, Juniperus communis var. nana,* and *Rosa mollis.* Archaeological excavations have revealed that *Betula pubescens* and even *Corylus avellana* were growing in the Faroes at the time of settlement around 800 AD. (or landnam, which is the Nordic expression). Most of the lowland, i.e. up to 200 - 300 m a.s.l., was covered with woodland or scrub at the time of landnam.

At Skógrøkt landsins we now have at programme of collecting plant material from as many of the remnant populations of the local dendrovegetation as possible. Propagated plants from this material will then be used in replanting activity of various kind, including sale to the private garden market.

In the mid seventies, the first private garden landscaping firm was set up in Tórshavn. Previous to this, only part time occupation had been possible in this profession here. In 2000 there are 3 such firms in Tórshavn alone, and they employ 10 people on a permanent basis, and additionally quite a few during the summer time. Both Tórshavn and Klaksvík city councils have appointed posts as city gardeners, and other councils are likely to follow them.

These companies and institutions mentioned above are all heavily dependent upon the plant production and sale provided by the Skógrøkt landsins. In addition, we also sell plants to garden centres and to private garden owners..

A survey 14 years ago of a 50 year old *Pinus contorta* stand showed an annual production > 7 m^3/ha/year.

In the seventies, a local teacher began to develop his skills and perfection in the art of woodturning using only Faroese grown wood. Today Ole Jacob Nielsen is well reputed for his wood turning art, both at home and abroad, where he has been invited to several exhibitions. Others are following in his footsteps.

The afforested areas are very popular recreation sites for the public, and some locals even have adapted to the leisure of picking mushrooms there in the fall. In addition, these areas are very popular sites for both ornithological and entomological observations. In the larger towns, the plantations also play an instrumental role for the outdoor programmes offered to children at the various day nurseries.

It is remarkable how often trees, shrubs, or just twigs or flowers are used as surroundings or the background for illustrations, TV-interviews and other cultural events here. Tórshavn town council has decided to hand out 2000 larch trees to the citizens, to mark the millennium.

So, I believe we are building up both social capital and natural capital, to quote professor Amdam.

A few years ago, one farmer bought some plants of *Abies sp.* to grow for Christmas trees and decoration greenery. This summer we provided another farmer with a few *Lupinus nootkatensis,* in a small scale trial to combat the big erosion problems in his grazing areas.

So, we are also seeing the beginnings of the build up of economic capital?

JAMES MACKENZIE

The Future of Woodlands in Shetland

SAMANTEKT
Skóglendi myndar aðeins smábrot af landslaginu á Hjaltlandi, sem einkennist helst af mýrum og móum og stafar það ekki aðeins af hafrænu loftslagi heldur einnig af 5000 ára búsetu mannsins. Leifar af upprunalegu skóglendi tóra aðeins sem stakar hríslur eða smáhópar trjáa. Allir skógar á Hjaltlandi eru gróðursettir og samanstanda einkum af innfluttum tegundum. Nokkrar þeirra, s.s. sitkagreni og japanslerki, hafa náð allgóðum vexti. Sauðfjárstofninn á Hjaltlandi er nú álíka stór og á Íslandi og hefur hann stækkað mjög undanfarin ár vegna styrkja. Ofbeit er á mjög háu stigi og talsvert skortir á skilning stjórnvalda á vandanum. Hins vegar eru möguleikar fyrir hendi á endurheimt skóglendis, einkum til skjóls og yndisauka, bæði með innlendum og innfluttum tegundum. Neikvætt viðhorf flestra eyjaskeggja og lítið fjármagn takmarka umfang skógræktar, en áhugi á garðrækt og trjárækt eykst ásamt umhverfisvitund. Vonast er til að þetta verði til þess að auka áhuga á endurheimt skóglendis.

Introduction
Woodlands constitute a tiny fraction of the Shetland landscape which is dominated by peaty moorland, the result not only of an extreme oceanic climate but also of 5,000 years of human occupation and land-use. Only scattered groups or individuals of relict trees survive from the original pre-settlement wooded areas: all other woodlands in Shetland are plantations, mostly of "exotic" species.

Agriculture in the twentieth century brought about a rapid intensification of sheep-rearing in Shetland, on both enclosed and un-enclosed land. This form of monoculture is, however, at crisis level and indicates the need for a more sustainable and diverse system of land-use. Changes in climate also reinforce this need.

There are, consequently, opportunities for the re-establishment of woodlands in Shetland, using both „native“ and „exotic“ species, for a variety of purposes. Although received cultural attitudes and financial resources currently limit such re~establishment to small-scale projects, public interest in horticulture and arboriculture is growing, as is an awareness of conservation issues. Examples of successful woodland establishment and management, and research into aspects of forestry that pertain to Shetlands climate and geophysical characteristics, are of vital importance in order to stimulate this growth and contribute to the future well-being of the environment.

An unlucky day for trees?
13th June, 2000 broke Shetland records for the strongest winds yet recorded for that month with gusts reported up to 140 kph. Quite literally it was a black day for arboriculture, horticulture and agriculture, due to the complete lack of precipitation and cloud cover, and to the high levels of salt deposition and abrasion. Trees, shrubs and other garden plants, vegetable crops - even grassland - were burned, and for weeks afterwards the uncanny and untimely sound of dry rustling leaves could be heard in the tree canopies and on the ground.

One might have been forgiven for thinking that there was no future for woodlands in Shetland. There had, however, been an unusually warm and sunny spring, and tree growth had been good. For an arborist 13th June and the following summer would become a testing time - to discover which species and provenances suffered least initial dam-

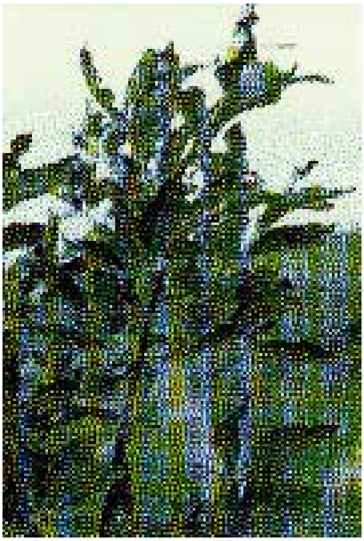


Fig. 1. *Salix alaxensis* after the storm: surprisingly little damage.

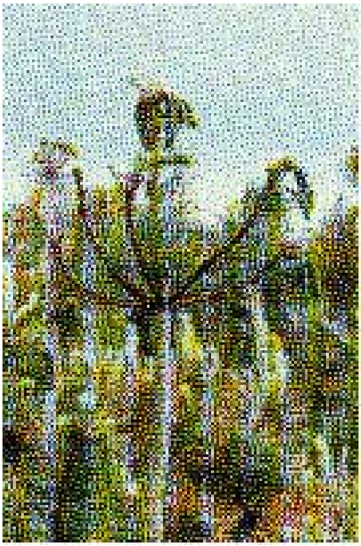


Fig. 2. *Pinus contorta* after the storm: not so good-looking.

age, and which recovered most quickly, while taking into account factors such as age, soil conditions, etc. [Figs 1 & 2].

At the same time it became important to convey a message of optimism to people who were perhaps filled with despair or sorrow at the mess their trees were in: “Don’t worry, if your tree is reasonably healthy and well established it will recover in time ... take such and such precautions ... *and isn't it a good thing you’ve got some tree shelter for your garden, otherwise the damage would have been far, far worse.*"

Furthermore, an arborist could hardly avoid thinking: “If certain kinds of trees can survive such weather conditions without undue damage, why not use them to shelter not only gardens but agricultural crops as well?” for there would have been significant financial burdens incurred by farmers and growers on that day.

And one last thought: “Why is it that some people who live in Shetland go on insisting that trees 'just don’t or can't grow here', when all the evidence shows that they do - and can stand up to phenomenal extremes of weather?”.

Pre-history

It has indeed often been said that Shetland is empty of woodland because of the climate, windiness being the prime cause. Severe storms, however, damage other vegetation as pointed out above, yet the islands continue to support a variety of grasses, herbs and heather, as well as isolated relict trees and shrubs, and pockets of planted woodland [Fig 3].

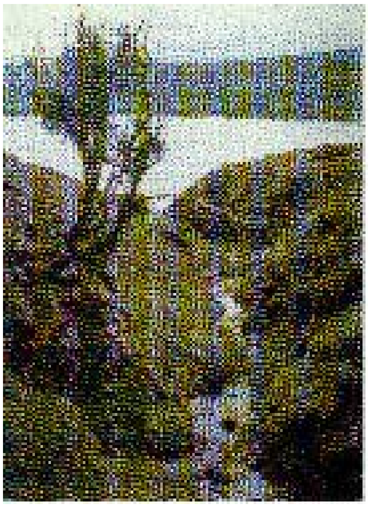
Paleo-ecological research indicates a sudden decrease of tree-cover about 5,000 years ago (Johansen 1985, Bennett et al. 1992). This appears to have coincided with agricultural settlement on a large scale. One need only to look at Iceland to see how only 1200 years of human occupation has severely reduced tree-cover (The Forestry Fund 1994).

The late Professor David Spence hypothesised that 5000 years of vegetation change was as much due to animal grazing and trampling as to climate (Spence 1979). This followed a period of initial burning and felling, to which some Shetland place-names deriving from Old Norse bear witness, e.g. “Brunt Hamarsland”.

Remains of trees are found in peat banks and in bogs, even on quite exposed land. It is notable also that the eight known surviving aspen *(Populus tremula)* in Shetland, are all on cliffs exposed to the Atlantic ocean and its prevailing winds. While one might imagine they had been driven to the most inhospitable locations by hostile forces intent on their destruction, they nonetheless continue to survive. Four of them have now been brought into cultivation. It remains to be seen how they grow in other more favourable locations.

Likewise, *Betula pubescens* (Downy birch), which was proba-

Fig. 3. Relict *Sorbus aucuparia,* Ronas Hill, North Mainland.



bly the main component of Shetlands ancient woodland, survives in only five sites, two on high cliffs above the sea (like the aspen) and three on remote holms on lochs in the exposed plateau of North Roe in the north of Shetlands mainland [Fig 4]. Alder (no live relicts), hazel (just two relicts!), rowan, willow and juniper of which there are more survivors, were other components of this woodland. But pollen deposits in loch beds suggest that common ash, oak and wych elm may also have been present (Bennett et al. 1992). Pollen of Scots Pine *(Pinus sylvestris*) has also been found, and it is tantalising to think that the Caledonian forest (or Norwegian one for that matter) may have reached as far as Shetland!

Fig. 4. *Betula pubescens* and *Salix*, Inniscord Loch, North Mainland.

History

The only woodlands in Shetland today, however, are plantations, mostly dating from the 19th and 20th centuries. The ancient capital of Shetland, Scalloway, and the gardens of Busta House, a large mansion near Brae in the north mainland, have old sycamores *(Acer pseudoplatanus)* and wych elms *(Ulmus glabra)* that may date back to the 18th century

It was the lairds (Scottish landowners), merchants and clergy, who were largely responsible for these plantations. Their respective "tenants", "customers" and "flocks" were in more or less feudal thrall to them until the late 19th century. Fishing, subsistence farming, and the infamous "truck system" kept the majority of Shetland's rural population in hand-to-mouth poverty and debt, with the whip-hand of organised religion to keep any rebellious spirits down.

No wonder then that few of the tenants' houses had room for anything more than the crops necessary for survival next to them. An exception sometimes was the common elder *(Sambucus nigra),* the pith of whose shoots was used as wicks for tallow lamps ("kollie lamps").

It may be that two often-heard expressions in Shetland: "Trees spoil the view" and "Trees are foreign to Shetland", have their roots in this dark period of history, which culminated in the lairds evicting tenants throughout the highlands and islands of Scotland in their thousands, and replacing them with sheep. Trees then might, with some justification, have been regarded by the majority of Shetland people as the idle playthings of the (usually Scottish) rich, who treated their fellow humans with such contempt.

The present

The Crofters Act of 1886 brought security of tenure to the smallholders of the north and west of Scotland, but in many cases the crofts they were given security of were of poorer quality than what was available to them before. They didn't get "their" land back. Meanwhile the lairds had introduced sheep ranching on a large scale; the tenants were obliged to follow the same practice by market forces.

In 1880 there were 80,000 sheep in Shetland, 247,000 in 1950 and 424,000' in 1998 (Scott & Palmer 1987, Spence 1979, SIC 1999). This accelerating monoculture has had profound and deleterious effects on Shetlands already fragile vegetation. Generous subsidies have encouraged crofters and farmers to increase sheep numbers to undoubtedly unsustainable numbers, in both ecological and economic terms. Large tracts of heather moorland have been converted to grassland by application of lime and fertiliser, and surface seeding. On nearly all "in-bye" land arable crops have been given over to grazing. Hay making has been superseded by silage making, with unwieldy machinery compacting soils, which are made wetter by the increasing rainfall which appears to be the main effect of global warming on Shetland's climate.

Fig. 5. Plantation with *Picea sitchensis* at Kergord, Central Mainland.

On the peaty hill land, the replacement of heather by shallower rooting grasses which are intensively grazed, causes soil instability. In winter such ground becomes literally a bog or a swamp. Fertilisers are quickly leached away. Overgrazing on hill land may also have contributed to several recent landslides.

As far as woodlands are concerned, the 20th century might justifiably be termed “the era of sitka spruce” in Shetland. The islands' largest grouping of trees (45 ha of shelterbelts), at Kergord in the central mainland, has a high proportion of this species, planted between about 1910 and 1985 (Fig. 5). The highest of these trees average 16 metres, while the “champion” tree of Shetland is a Kergord sitka spruce of 19 metres height, with a girth at breast height of 1.9 metres. Kergord also has a fine collection of broadleaved and other coniferous trees, including an impressive *Araucaria auracana.*

Later, post Second World War plantations in Shetland were government subsidised experimental shelterbelts: nearly all were coniferous, with lodgepole and mountain pine nursing sitka spruce, according to classic Forestry Commission models. All, however, lacked continuity of management. There was no thinning regime, and no advice given to anyone by anybody on how to deal with a mature, narrow (e.g. 30 metres wide) coniferous shelterbelt. Consequently, progressive windblow has become a major problem in these spruce dominated plantations- which rather defeats their purpose as shelterbelts.

In Kergord, however, Japanese larch was used as an outer “defence” to several of the shelterbelts. This species, although not providing the vertical “wall” to prevailing winds that sitka spruce can, has proved much more wind firm, at least on relatively mineral soils. All the plantations at Kergord, however, fell into neglect in the latter part of the 20th century- with sheep gaining entry and destroying a substantial under storey of shrubs- until 1985, when Shetland Amenity Trust took over the management of these and several other mature plantations.

The future

There are some small signs that there will be a change to land use dominated by over-production of sheep. *First and foremost,* the bottom has, not surprisingly, dropped out of the market, with over-production throughout the EC being aided by lack of consumer confidence in meat products. However, subsidies remain at present based on quota numbers, which do not necessarily relate to land areas occupied by sheep. Little alternative has yet been offered by government agencies apart from “set –aside” schemes for arable land- which have little relevance to Shetland - and conservation schemes which do little more than “mothball” farms and crofts. Meanwhile, the local government's Development Department still hands out lime and fertiliser grants to keep reseeded hill land “productive”.

Secondly, there is a younger generation of crofters (with some older and wiser ones too), who have an increasing “environmental awareness". It should be stated at this point that crofting, for the majority of those Shetlanders who engage in it, is *not* their primary occupation. The subsidies exist primarily to prevent rural areas from being de-populated. That is laudable, but if those subsidies help to destroy the land that is the basic sustenance of the rural areas, what is the point?

Thirdly. there is, for want of a better phrase, “the conservation movement" which comprises several organisations including the government agency Scottish Natural Heritage (SNH) and individuals. Unfortunately there is often conflict between SNH and crofters (and fishermen) who regard it as a dogmatic and unaccountable organisation set on depriving Shetlanders of their “traditional” livelihoods.

Johnston (1989) suggests the formation of a land-users' group, which would allow for more accountability from government agencies and for community driven aspirations and decision-making to be at the core of future land-use policies.

So where does the future of woodlands in Shetland fit into all of this? It has to be admitted that at present trees and woodlands are marginal- not only geographically but culturally and politically. A recent consultation document, produced this year by Shetland Islands Council (SIC), stated: “Shetland's landscape is one of extensive vistas in which almost every building or development can be seen. As *screening with trees* is *not a practical proposition* [my italics], the first design principle is to seek locations which have some enclosure from the surrounding land form or in which the visual impact can be minimised” (SIC 2000).

This statement sits rather at odds with reality, in which many houses have gardens with trees and, as has been demonstrated above, and as can be seen by those who wish to see, there has been some considerable success in growing trees in the past century. It is a reflection of the fact that the Council has no landscape architect or equivalent to the Faroese “city gardener” in its employment. And in spite of the fact that Shetland Amenity Trust (SAT), which has fifteen years' experience of managing, growing and planting trees, is core-funded by the Council's oil revenues, there seems to be a complete ignorance of the Trust's aims and achievements.

Demonstrating that certain trees and woodlands can grow in certain locations remains, however, central to Shetland Amenity Trust's woodland strategy. Under the auspices of the Millennium Forest for Scotland Trust (MFST) and the Forestry Commission's Woodland Grant Scheme (WGS), together with aid from SNH and EC grants, a rolling programme of small community woodlands has been initiated, with a total of 6.5 hectares being completed this year.

Another initiative, sponsored by the readership of a leading UK Sunday newspaper and an organisation called Future Forests, should result in a further two hectares being planted in the vicinity of Lerwick, Shetlands capital, next year. Other new woodlands, funded by the WGS, currently add up to 20 ha, while mature and semi-mature woodland in Shetland constitutes a total of approximately 25 ha., much of which is being actively managed or extended.

There is plenty of willingness among the general public to plant trees and woodland. The local horticultural industry is thriving, and enquiries to Shetland Amenity Trust asking for advice on tree planting are numerous. There is very good encouragement from the Highland Conservancy of the Forestry Commission, and the Forest Research branch of the same organisation have lately sponsored several trials in Shetland. The affiliation of Shetland Amenity trust to the Nordic Arboretum Council (NAU) has been extremely fruitful, with new species and provenances not available on the UK market, being tested and propagated.

Conclusions

Two political/economic factors are required to ensure that woodland development in Shetland becomes more than a marginal or “extra-curricular” activity-

- Changes in agricultural (or land use) policy and practice.
- Changes in local government attitudes and policy towards trees/woodland and land use.

The main agricultural incentive towards woodland establishment is the nationally administered Farm Woodland Premium Scheme (FWPS) which is run concurrently with the WGS. Grants of up to £100 per ha. for 15 years are offered, which compensate for the number of sheep excluded from planted areas. The WGS offers a basic £ 1,350 per ha. for planting broad-leaves and £700 per ha. for conifers, with various supplements. Uptake in Shetland, however, is currently low for these schemes.

One may conclude that there is good nationally provided incentive for woodland establishment. But until emphasis on sheep production as being the only practical form of land use in Shetland is as drastically reduced as the number of sheep themselves, one may not expect much more than a token move in realising the incentive.

The SIC does very little to promote tree planting. In fact, I may go so far as to say that trees are regarded by the SIC largely as a joke. It is ironic that the recent hurricane force winds would not have damaged so many vegetable crops, both agricultural and domestic, had there been more protection from shelterbelts even to the level of hedgerows.

Furthermore, the SIC does little more as far as land use is concerned, than prop up the existing agricultural system with its lime and fertiliser grants. It could take a more constructive attitude towards what is evidently a crisis in both ecological and economic terms for Shetland’s agriculture, for example by promoting and steering the aforementioned land-users group.

One avenue (tree lined of course!) that may prove beneficial to such a change in attitude, is the link to the Nordic countries. Overtures have been made by the Faroese Prime Minister to invite SIC councillors and officials to attend meetings of, or even affiliate to, the Nordic Council of Ministers. Given that, as I understand, the NAU is funded by this council, there is a chance that environmental matters, and trees and woodlands in that context, may be discussed and taken more seriously, at least in terms of their amenity and landscaping value.

Furthermore research into more economically relevant aspects, such as shelterbelts, short rotation coppice of suitable willows and poplars for small scale biomass production as an agricultural option, and/or into the use of woodlands in soil improvement programmes, perhaps using mycorrhiza, would do much to initiate more than a mere interest in biodiversity. It would provide for practical adherence to the protocols agreed at the Rio de Janeiro summit on biodiversity and the Kyoto conference on global warming.

It is my earnest hope that Shetland Islands Council will take a more pro-active and imaginative stance towards woodland development in Shetland, for the benefit of the people it serves, and the land it administers on their behalf.

(All photographs are property of Shetland Amenity Trust)

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ALISON J. HESTER

Grazing Management and Forest Regeneration in Marginal Areas

SAMANTEKT
Fjallað er um helstu atriði er varða beitarstjórnun og endurheimt skóga á jaðarsvæðum, þ.e. þar sem óblítt veðurfar og ófrjór jarðvegur takmarka landnýtingarmöguleika. Stór hluti Skotlands fellur undir þessa skilgreiningu, en þau atriði sem hér er fjallað um eiga einnig við í öðrum löndum við Norður-Atlantshaf, Beit, bruni og skógarhögg yfir langan tíma hafa mjög rýrt náttúrlega skógarþekju Skotlands, sem er nú innan við 10% af mögulegri þekju, og áframhaldandi hindrun á endurnýjun skóga af völdum beitar sauðfjár og dádýra veldur áhyggjum um framtíð náttúrlegra skógarleifa. Skref hafa verið stigin undanfarin ár til að hamla gegn þessari þróun og stuðla að nýskógrækt, en í þeim felst yfirleitt að girða grasbítana frá. Hins vegar er spurning hvort ekki megi stuðla að endurnýjun skóglendis án þess að girða, t.d. með því að hafa stjórn á fjölda grasbíta eða að stjórna beit þeirra á annan hátt. Fáar rannsóknir liggja fyrir hvað þetta varðar en vísbendingar eru um að í Skotlandi gætu tiltölulega beitarþolnar tegundir, s.s. birki, fjölgað sér ef þéttleiki sauðfjár er innan við 50 kindur/km^2 (1 kind á hverja 2 ha lands) og þéttleiki dádýra er innan við 5 dýr/km^2. Í greininni er farið yfir helstu rannsóknaþarfir, s.s. varðandi þekkingu á flakki og fæðuvali grasbíta og beitarþoli mismunandi trjátegunda. Loks er fjallað um hvernig nota megi rannsóknaniðurstöður við ákvarðanatöku um landnýtingu til að ná settum markmiðum. Mikil rannsóknaþörf er enn fyrir hendi en sérstaklega er þörf á að samræma niðurstöður frá mismunandi rannsóknasviðum.

Summary
This paper considers some of the main issues affecting grazing management and forest regeneration in what have been termed 'marginal areas', i.e. where land use options are limited by the harshness of climate and soils. Much of Scotland, which forms the focus of this paper, falls into this category, but the issues which are discussed here have parallels in many other North Atlantic countries. Many years of grazing, burning and wood cutting have severely depleted Scotland's natural forest cover to less than 10% of its potential area, and the continuing widespread suppression of tree regeneration, particularly by sheep and deer, has led to increasing concern about the future of the remaining natural forest areas. Thus in recent years steps have been taken to redress this balance by actively encouraging new native forest development. Management needs to achieve this aim are discussed in this paper, together with the key research issues involved in designing appropriate management options for forest regeneration under different conditions. I conclude by discussing how we can best integrate complex research findings into accessible and practical advisory tools for land managers, exploring where we currently are in relation to this aim.

Introduction
In 'marginal' areas, such as the Scottish uplands, natural and commercial forests together provide many benefits, contributing to the environment and the economy through a range of outputs such as timber, shelter, amenity, landscape and conservation. In Scotland, the commercial forests are normally fenced to exclude herbivores so that the trees can grow fast and with good form. However, most natural forests are unfenced and thus open to any herbivores. Therefore this paper focuses on natural forests, where grazing management is a major issue.

In the British uplands, extensive grazing, particularly by sheep, has traditionally been one of the main land uses. The income from sheep (and the grants they attract) has for many years been of fundamental importance to the economy of such areas where other land use options are so restricted. In addition, wild herbivores are also widespread in these upland areas: those which impact most widely on trees are red and roe deer, but more locally rabbits, hares and small mammals such as voles can have major impacts on young trees. Red deer have traditionally been 'managed' for shooting on the large estates of Scotland and so their densities can be as high as 30 per km^2 in some areas. These many years of grazing have shaped the landscape dramatically, resulting in large tracts of open ground. Natural forest remnants are now restricted to only about 3% of the land area of Scotland, with perhaps another 2% of montane scrub (Mackenzie 1999; Hester 1995; Gilbert, this volume), whereas estimates of how much forest/scrub the land could actually support are close to 50% of the land area (Towers, this volume). Within the large expanses of open ground, these few remaining natural forest areas provide valuable shelter and early grass growth for both sheep and deer (Staines 1976; Grace & Easterbee 1979), but often the densities of wild and domestic herbivores have been too high to allow regenerating tree seedlings to survive and grow, and many hundreds of years of such heavy grazing have had enormous impacts on the state of the remaining forested areas, with many old trees and very few young ones. Figure 1 shows an area of the Cairngorms in the Scottish Highlands where natural forest cover is relatively high (note the dense blocks of forest are commercial plantations): the natural woodland is mostly scattered birch and pine.

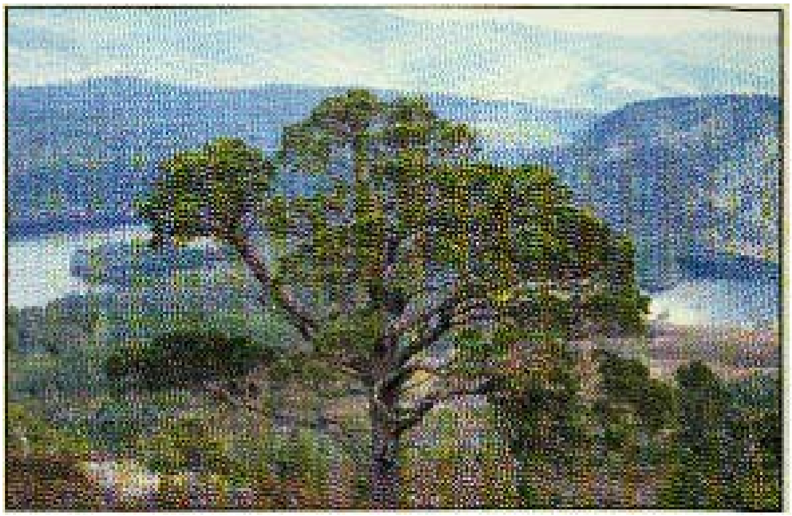

Figure 1. View of the western Cairngorm massif and part of the Spey valley, Scottish highlands. Scattered natural woodland (mainly birch and pine) and conifer plantations are visible.

The situation just described, therefore, is one of conflicting land uses, i.e. a severely depleted forest resource and large numbers of free-ranging wild and domestic herbivores for agriculture and sporting purposes, which are restricting new regeneration. This situation is common to several North Atlantic countries. However, changes have been taking place in the past 10-20 years, with a gradual increase in awareness of the issue and the urgent need to actively promote native forest protection and expansion. In the UK there is now considerable effort aimed at redressing the balance by actively encouraging expansion of the native forest area through natural regeneration and planting schemes, many of which are aided by Government grants. In the last five years, for example, establishment of about 400 km^2 of new native forest has been grant-aided (0.5% Scotland's land area) (Mackenzie 1999). However, the grants are still generally tied to complete removal of large herbivores by fencing, rather than the development of policies which combine reduced grazing with regeneration, primarily because large herbivore exclusion is still perceived as the most reliable way of letting young trees establish and grow into forest. Yet for many reasons well described elsewhere (e.g. cost, snow damage, bird deaths, etc: Hester 1995; Beaumont et al. 1995; Gilbert, Horsefield & Thompson 1997), this is no longer considered the best solution and it is now generally agreed that the most desirable approach is not to fence, but to control herbivore numbers more sensitively, so as to achieve forest regeneration and grazing together (Hester & Miller 1995).

Management needs

There are two fundamental needs of a land manager wishing to encourage forest expansion whilst still grazing the land: (1) first, they require practical guidance on different densities and species of herbivore required to achieve whatever forest expansion they want. All land managers are operating within a set of constraints, for example financial, the herbivores they already have, and the availability of land; (2) second, they require a range of options to suit these constraints. For example if a land manager has only sheep and it is uneconomic to purchase cattle and provide them with winter housing and feeding, then that manager will require an option which uses sheep. Equally, if only summer grazing is recommended for forest regeneration, but there are no land resources to overwinter sheep, then it will not be possible to adopt that management unless it is possible to pay to overwinter the sheep elsewhere, and so on. So the management options also must include a strong economic component to be able to assess the feasibility of different grazing scenarios and, if the practical grazing (for forest regeneration) options do not fit economically with land managers' needs, then the Government grants need to offer greater incentives to make it worthwhile. As my own area of expertise relates to (1) above, this is where the remainder of this paper will focus, but other papers in this volume consider many of the relevant economic issues.

What is currently known about appropriate herbivore densities to allow tree regeneration in complex upland landscapes such as in Scotland? Examination of the relevant literature (published and unpublished) reveals that very few studies have been done and very little is known. As far as I am aware, the only published estimate for sheep is from one experimental study (Hester, Mitchell & Kirby 1996), suggesting that 50 sheep per km^2 might allow sufficient regeneration, at least of more grazing-resistant tree species such as birch. There have been slightly more studies of deer densities and tree regeneration (Beaumont et al 1994; Stewart 1996), most of which showed marked increases in regeneration when deer numbers were reduced to about 5 per km^2, but at no sites were the density:regeneration relationships statistically significant. This is primarily because most studies were carried out in single, unreplicated areas, with huge variation both between and within sites, caused by a whole range of other factors such as availability and distribution of other vegetation, topography, exposure and disturbance. Examination of published information on other herbivores, such as rabbits, hares or voles, reveals no density recommendations to date.

To summarise, in these complex upland landscapes where the herbivores can range widely, it is still not possible to recommend specific grazing management options to ensure successful regeneration under a range of different conditions. In view of this scarcity of information, it is not surprising that Government grant schemes still normally require complete removal of large herbivores, and this will no doubt continue until reliable grazing management prescriptions are developed for these upland areas. Let us therefore consider what are the key outstanding research issues, and how they can best be approached.

Key research issues

In these complex upland landscapes, simple herbivore density estimates mask the highly variable distribution and severity of their impact. Our understanding needs to increase before predictions and recommendations can be made to reconcile grazing management with forest regeneration over large areas of land. Three main areas of study can be identified, each one operating at a different scale, from herbivore ranging behaviour at the landscape scale, through forage preferences at the site scale, to sapling responses to browsing damage at the individual plant level. Let us consider each in turn below:

Herbivore ranging behaviour

At the landscape scale, an ability to predict ranging behaviour and habitat use by different herbivore species is a crucial starting point, as it determines when an animal is actually likely to be present in the area where young trees are growing. Indeed, this is one of the main reasons why simple herbivore density/tree regeneration relationships are so hard to find. In simple terms, one can predict likely habitat use based on vegetation preferences from first principles, and several models exist which do just that, based on biomass and digestibility of different vegetation types at different times of year. Such predictions have been found to be accurate if the only factor affecting animal movements is the vegetation. But clearly the predictions will not be accurate if other factors, such as climate, disturbance, accessibility, also strongly affect herbivore movements. For example, it is not useful to predict that animals will focus on a particular vegetation type if for other reasons they never visit the area where that vegetation type grows (e.g. Stewart 1996). Large herbivores, such as red deer, range widely in these open landscapes, and their use of forest areas or new areas of regeneration is known to be strongly affected by factors other

Figure 2. Four-year old pine saplings subjected to simulated browsing damage (50% of shoots) in the previous year (Hester, unpublished data).

than just the young trees, which are not necessarily related to the trees, such as disturbance, other vegetation types present, exposure and social behaviour.
Sheep, being domestic, are more controllable, but without active shepherding their use of different areas is also highly variable for the same reasons.

How can we predict and, more importantly, test, how these other factors affect herbivore range use? Traditionally, radio-tracking was one of the main methods used to describe the positions of herbivores, but it is time-consuming and often very difficult to locate animals in large mountainous areas. This approach is therefore of relatively limited value in this kind of terrain. However, recent developments in Global Positioning Technology have opened new, exciting opportunities in this area of work (as well as in many others) (Pastor & Naiman 1992; Pastor, Moen & Cohen 1997).
To give a Scottish example, research at the Macaulay Land Use Research Institute has used Global Positioning Systems to track red deer movements to an accuracy of < 10m (Sibbald in press). Each animal has a collar fitted with a GPS and data recorder, which records the location of animal as frequently as required, and data is downloaded remotely via a radio link onto a computer every few months. Over the course of a year, two distinct scales of variation can be identified from such work: the first is a clear seasonal difference in large scale range use; the second is much smaller scale variability in location on different days or times of day. At this level of resolution one can match location to vegetation, weather, visitor numbers (disturbance), and so on, to elucidate the main causes of the variation recorded. This type of technology thus represents a real breakthrough in a currently poorly understood area of research, as it will facilitate more widespread collection of data to aid in the development and testing of hypotheses about the relative

importance of different factors in determining herbivore range use.

Forage preferences

Once a predictive understanding of when the animals are likely to actually visit a particular area is gained, it is at this second level that an understanding of diet choice is fundamental. This concerns not only the relative preferences for different tree species by different herbivores, but also the range of other factors which affect these preferences, such as surrounding vegetation and time of year. Preferences for different tree species have been relatively widely studied in a range of countries (e.g. Mitchell, Staines & Welch 1977; Van Hees, Kuiters & Slim 1996), resulting in a reasonable consensus as to which tree species are most preferred by large herbivores - examples of more preferred species are *Salix spp, Sorbus aucuparia, Populus tremula,* and examples of less preferred species are *Pinus sylvestris, Juniperus communis, Picea spp.* This is an important issue for a land manager who wishes to encourage regeneration of particular tree species. For example, *Pinus sylvestris* is likely to regenerate at higher deer densities than *Salix spp,* and there are good examples of this pattern in some of the Scottish estates which have been reducing deer numbers to allow forest regeneration (Beaumont *et al*. 1994). It is also well established that, within a species, some individual saplings are more preferred than others, for a range of reasons such as morphology, visibility and chemical content (Mitchell *et al*. 1977*;* Danell *et al.* 1991; Edenius *et al.* 1995) However, both the above factors are strongly influenced by surrounding vegetation; it affects food choice, sapling visibility and accessibility. Finally, time of year also interacts with all the above; many factors change through the year to alter herbivore forage choice, such as biomass and digestibility of other forage, and visibility of the saplings themselves.

To summarise, a range of factors interact even at the level of forage preferences to determine choice of diet. The crucial issue for designing robust management options is to understand and be able to predict how, when and why these factors might interact.

Sapling responses to damage

At the smallest scale, factors affecting sapling responses to damage are very similar: different species respond differently to damage, and the response also depends on the age and size of the sapling: younger, smaller saplings are generally more badly affected by browsing damage (Chapin *et al.* 1995). To give an example, *Pinus sylvestris* is generally one of the less preferred species of browse, but it is also one of the least tolerant of damage (Miller *et al.* 1982; Millard & Hester in press). Even if it is less heavily browsed than a species such as *Sorbus aucuparia,* which is very tolerant of damage (Miller *et al.* 1982; Millard & Hester in press), it may still be more badly affected. Therefore browsing preferences for different tree species need to be considered along with sapling tolerance. Timing and severity of damage are also fundamentally important and their effects also vary between different tree species (Danell et al. 1994; Hester et al. 1996). Furthermore. as with forage preferences, surrounding vegetation, as well as soils, affect competition and resource availability, which may all influence a saplings ability to regrow after damage (Hester et al. 1996).

Therefore, as with foraging preferences, a complex of factors all interact at the sapling level, and all need to be understood to some degree to be able to make reliable predictions about browsing impacts on saplings under different conditions.

Integration

Most research to date has focused on particular questions or small groups of questions, usually within only one of the three main approaches described above. Such types of studies are continuing in many different countries, often in isolation rather than as part of a larger integrated programme Thus, I suggest that the most pressing need at present is to move towards much greater integration of such work at a whole range of scales from the landscape, where a large number of interacting factors require to be studied, down to the individual plant where highly controlled experiments can be carried out.

Research at the landscape level (e.g. Fig 1) has the advantage of describing 'reality'; but the disadvantage is the huge variability and the difficulty of isolating which factors or combinations of factors have caused the results measured (e.g. Beaumont et al. 1994). Using only this approach can lead to misleading conclusions. It can be combined with research at medium geographical scales (ha-km), using semi-controlled experiments, for example, where large replicate experimental plots are set up within a naturally variable landscape, with a range of factors varied explicitly (such as herbivore density, timing of grazing, different sapling species) to examine their influence on herbivore behaviour and sapling damage (e.g. Hester et al. 1996). Such experiments tend to be labour-intensive and expensive to set up, with fencing costs and animal management, but they can yield informative, field-based results. Slightly more controlled may be an experiment limited to a single vegetation type, with small-area (ha or less) control of precise timing and density of herbivore occupancy (days and weeks). These experiments are also very labour intensive, but can enable isolation of specific factors which are generally confounded in more variable field situations. At the smallest scale (e.g. greenhouse, growth chamber, animal enclosure), completely controlled experiments can be designed where most factors are tightly controlled (e.g. Millard & Hester in press; Fig. 2). The advantage of this type of experiment is that one can isolate specific factors and examine them in great detail, giving important insights which cannot normally be gained from less controlled experiments. However, the disadvantage is that such experiments can be so far removed from reality that the behaviour of herbivores and/or saplings is not always representative of the field situation. There is an important place for these experiments, but they need to be designed with care and closely linked to relevant field experiments. To summarise, there is an important role for integrating all these approaches, as they can complement each other if well designed.

Complexity to simplicity - **returning to management needs**

In this section I will consider how to translate the above complexity into simplicity, so as to address the needs of land managers

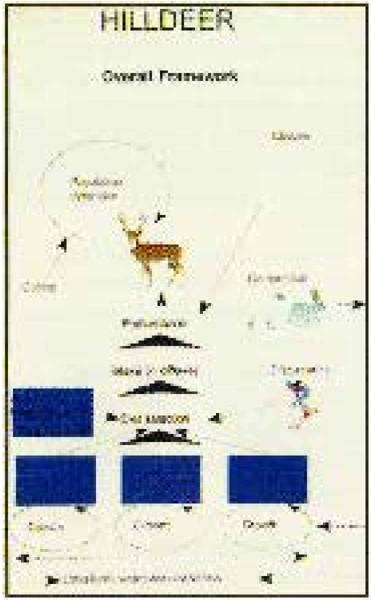

Figure 3. Diagrammatic representation of the Decision Support tool HILLDEER (MLURI 1998).

and/or policy makers, as outlined earlier in this paper. It should be clear how the above research approaches can contribute to developing the required understanding about herbivore impacts on forest regeneration, but the needs of managers/policy makers are to have simple and easy to use tools to aid decision-making on appropriate herbivore numbers to achieve a range of desired end-points. Therefore the research results will only be of direct value if they can be translated into something that people will actually be able to apply and benefit from. One approach is the development and use of Decision Support Tools (DSTs) which can be run on personal computers, with a small information input that is either: (a) easy for the user to collect, or (b) already in the DST (e.g. countrywide climatic data, land cover data).

The main requirements for a DST to be successful are: (1) they need to be easy and inexpensive to use; (2) they need to use robust data, and include information on the degree of uncertainty associated with the outputs - this is a crucial issue, as computer output can create the illusion of being unquestionable; (3) the data which the user needs to input should also be easy to collect; and (4) finally, the output needs to be appropriate, practical and straightforward.

One example of the underlying framework of a grazing DST is shown in Figure 3 (MLURI 1998). It was developed by a team at the Macaulay Land Use Research Institute to predict habitat use and impacts of different densities of red deer within large upland areas of Scotland (open range vegetation only). As indicated in the diagram, it incorporates a range of vegetation types, disturbance, other herbivores (sheep and rabbits) and climate, thus achieving the aim of integrating a range of information at different scales to produce simple outputs. The input requirements are straightforward: for example the approximate areas of different vegetation types (available from a whole Scotland dataset held at the institute) and the numbers of other herbivores. The user can manipulate deer numbers to investigate how habitat use might change, and can predict the impacts of different deer densities on the range of vegetation types present. It also links with a population dynamics model so that predictions on how different culls will affect reproductive rates and sex ratios can be obtained, both in the short and longer term.

DSTs can be very useful if well designed, and this is one of the best ways to integrate the kind of complex information described above and to make it actually work for practical land management decision-making. But there are still two main limitations to most current DSTs: (1) firstly, most are not yet spatially explicit, i.e. they do not incorporate information at the landscape scale on the impacts of vegetation pattern and topography on ranging behaviour, partly because of a lack of data and partly because the software and computing power have only recently become sufficiently sophisticated; (2) secondly, most of the available grazing models in the UK and elsewhere deal either only with open-ground vegetation or only with forest, because as yet we still have a poor understanding of forest use when it represents only a small component of a whole complex of vegetation types. For this reason, a scoping study is currently being undertaken to see where the main data shortages are, before we embark on new DST development for complex landscapes containing patches of forest within a range of other vegetation types. This would aid managers of areas where trees form only a minor part of the landscape but where tree regeneration is a major aim.

Conclusion

Grazing management for forest regeneration is a fundamentally important, yet highly complex, issue in countries such as Scotland, where natural forests have declined to such small remaining areas. Development of appropriate and sustainable management recommendations requires an integrated approach to a subject which encompasses many fields of expertise, from plant and animal physiology and ecology, through landscape science, to economics. It is only by integrating such approaches that we will be able to move towards the provision of sound prescriptions for a range of herbivore/forest regeneration options within a changing economic and political climate.

Acknowledgements

I am grateful to Throstur Eysteinsson for inviting me to present this work at the FBT conference in Iceland and for financing my visit. Thanks also to Angela Sibbald for providing information and a Figure on the GPS project work (Fig. 3). John Milne provided helpful comments on the manuscript.

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Skógrækt er landbúnaður

Landbúnaðarráðuneytið er fagráðuneyti skógræktar.

Meginhlutverk Landbúnaðarráðuneytisins er að stuðla að þróttmiklum og sjálfbærum landbúnaði og öflugri matvælaframleiðslu til hagsbóta fyrir framleiðendur og neytendur.

Viðamikil skógræktarverkefni eru skipulögð í öllum landshlutum. Markmið þeirra er meðal annars að klæða landið skógi, framleiða timbur og skapa atvinnu.

Í landinu er stunduð margskonar skógrækt af bændum, áhugamannafélögum, fyrirtækjum og einstaklingum. Landbúnaðarráðuneytið stuðlar að framgangi þeirra verkefna auk þess sem það vinnur að vernd gróðurhulunnar og uppgræðslu foksvæða.

Skógurinn er auðlind sem mun kalla á ný störf á landsbyggðinni og stuðla að fegurri sveitum.

Landbúnaðarráðuneytið

DIANA GILBERT

The Potential for the Restoration of Montane Scrub in Scotland

SAMANTEKT
Árið 1996 var stofnað til verkefnis sem stuðlar að endurheimt kjarrs í Skotlandi. Með kjarri er átt við gróðurlendi þar sem ýmsar meira eða minna uppréttar runnategundir allt að 5 m á hæð eru ríkjandi og er talið að slíkt gróðurfar hafi áður verið útbreitt í fjöllum fyrir ofan skógarmörk og við vesturströndina allt niður að sjávarmáli. Allmargar tegundir geta myndað kjarr í Skotlandi, þ.á m. nokkrar víðitegundir, einir, fjalldrapi og trjátegundir, s.s. skógarfura, eik, birki, reyniviður og blæösp sem vegna umhverfisins ná lítilli hæð. Kjarr er vart til lengur í Skotlandi og er leifar þess helst að finna á óaðgengilegum klettasyllum, innan um lyng (einir og fjalldrapi) og mjög sjaldan í skógarjöðrum. Sumar runnategundir eru jafnvel í útrýmingarhættu, t.d. loðvíðir. Kjarr hefur mikið gildi fyrir fuglalíf, ýmis smádýr og jurtir. Þá væri hægt að rækta kjarrkenndar tegundir í jöðrum skógarreita til að draga úr myndun skarpra skila í landslagi. Margt þarf að skoða ef takast á að auka útbreiðslu kjarrs. Auka þarf þekkingu á núverandi ástandi, takast þarf á við beitarvandann og jákvæðar og neikvæðar hliðar girðinga, auka þarf þekkingu á erfðafræði lítilla stofna og skoða þarf hvatningu til landeigenda í formi framlaga.

Background
Less than two percent of Scotland's land area currently supports semi-natural woodland. The maximum at the post-glacial climatic optimum has been estimated by a number of authors (McVean and Ratcliffe, 1962; Tipping, 1985 and Bennett, 1978) at over fifty percent, with some authors proposing that very little ground was open even on mountain summits. It has been suggested that man was beginning to impact on the forest area as much as six thousand years ago. Since that time forest has been systematically cleared to allow for crop production on low ground and extensive stock grazing on the hills.

Immediately after, and as a consequence of the Great War of 1914 to 1918 the Forestry Commission was set up with the precise remit of securing a strategic reserve in home-grown timber. In Scotland, this meant that native forest areas were, with few exceptions either replaced with exotics or ignored. Over the past fifty years there has been national and international recognition of semi-natural woodland as an important biodiversity resource and there is now considerable activity to safeguard and restore the most important communities, such as Caledonian Pine Forests and Atlantic Oakwoods, in order to meet international obligations.

The public perception of forests in Scotland may be changing from the image of a plantation, established well within the forest zone where timber growth is likely to be most viable, to a mixed canopy which includes the semi-natural woodlands. This forest, though, is still limited by deer fencing below the 450 metre contour, resulting in a distinct cut off between high forest and heath communities. All the restorative effort has been focused on high forest areas described as important through the European Community Habitats Directive (The Council of European Communities, 1992), and the Convention on Biological Diversity (Anon, 1994, 1996) legislation. The natural transitions between the true woodland habitats and their neighbouring grassland, heath or mire communities at high altitude remain largely forgotten and depleted.

This paper reports on the Montane Scrub Restoration Project (MSR) which was initiated in 1996 as part of an inspirational initiative called the Millennium Forest for Scotland, using funding from the newly established national lottery through the Millennium Commission. The project has been managed by Highland Birchwoods and was steered by the Montane Scrub Action Group (MSAG), a partnership of individuals, supported by their organisations, with interest and expertise in land use, conservation and upland research. As a first attempt to draw broad attention to these neglected habitats and to stimulate interest in their restoration, the project aimed to raise awareness through better understanding of the issues associated with their current distribution and the potential recovery of the communities.

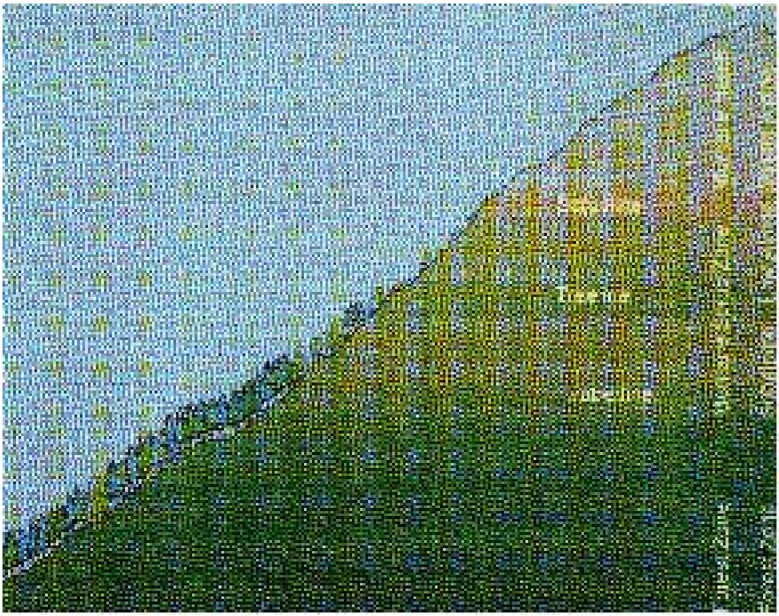

Figure 1. A diagramatic mountainside showing how trees of the forest zone are replaced by low growing scrub including stunted, twisted Pinus sylvestris and then by dwarf shrubs on the high tops, and how British terminology (left column) differs from that used in continental Europe (right column).

What is montane scrub?

The term scrub encompasses tree and shrub growth (excluding ericoid and prostrate dwarf shrubs such as *Arctostaphylos* spp., *Salix repens* L. and S. *herbacea* L.), less than five metres in height (Hester, 1984). Tansley (1939) split scrub into three main types, seral (or successional), sub-seral (in arrested succession) and climax. The interest of the project has been Scottish climax scrub found in situations where the climate restricts the upward growth of trees, specifically at high altitude but including the western 'oceanic' seaboard where the montane scrub zone approaches sea level (figure 1).

In the absence of a Scottish equivalent to 'krummholz', the MSAG defined montane scrub as ***'the stunted, crooked and twisted little trees in the zone of the treeline and the tall shrubs which naturally or potentially grow at the treeline and in the subalpine and low alpine*** (Mardon, 1997). Not only are we concerned with the tall shrubs of this zone but also the high altitude extremes of upland woodland types (table 1). Montane scrub is a transition between the forest and montane heaths or grasslands, where the tall shrubs form mosaics with both groups of stunted trees and with the heaths and grasslands.

The main phytosociological classification system in Britain, today, is the National Vegetation Classification (NVC) (Rodwell 1991) which describes vegetation types on the basis of the frequency (over 5%) and abundance of plant species found across the samples gathered for that purpose. Great emphasis is placed on the homogeneity of the vegetation stand for each sample. Due to this and the rarity of many of the tall shrub species given above few upland climax scrub communities have been described in the NVC. Otherwise, the tall shrubs are found across a wide range of different NVC community types (see Table 2). For example, Juniper is found in seven woodland, four mire, nine heath, three maritime and eight

Table 1. Shrubs and trees found in Scottish Montane Scrub.

All seven mountain willows:	S. *mysinifolia* Salisb. (Dark-leaved); S. *phylicifolia* L. (Tea-leaved); S. *lapponum* L. (Downy); S. *lanata* L. (Woolly); *Salix arbuscula* L. (Mountain); S. *mysinites* L. (Wortle-leaved) and S. *reticulata* L. (Net-leaved).
Juniper	*Juniperus communis* ssp *communis* L. (Upright) and *J. communis* ssp. *alpina* Celak. (prostrate)
Dwarf Birch	*Betula nana* L
Tree and shrubs species found above the timberline where these occur in a wind-pruned or stunted shrub-like form such as:	*Pinus sylvestris* L. (Pine); *Quercus* spp L. (Oak); *Betula pubescens* Ehrh. (Downy Birch); *Sorbus aucuparia* L. (Rowan); S. *rupicola* (Syme) Hedl. (Rock whitebeam) *Corylus avellana* L. (Hazel); *Populus tremula* L. (Aspen); *Salix aurita* L. (Eared Willow) S. *capraea* var. *sphacelata* Macreight (high altitude Goat Willow)

grassland vegetation communities (MacKenzie, 2000).

The emphasis of this vegetation classification system on the current distribution of plants in the presence of heavy grazing pressure down-plays the potential importance of structural diversity in a more natural vegetation community. It has also contributed to the neglect of the tall shrubs in vegetation surveys based on NVC, because they effectively remain invisible in the habitat descriptions.

More recently, Horsfield and Thompson (1997) suggested an unsystematic but useful scrub categorisation (Table 2.) based on McVean and Ratcliffe (1962) which at least allows meaningful discussion of the main types.

There are three typical situations in which montane scrub communities now survive:

- as remnants confined to high valley walls and cliffs (alpine willow scrub), out of reach of mammal herbivores,
- as a component of a *Calluna vulgaris* L. sward (alpine juniper scrub and dwarf birch scrub).
- and, very rarely, as a fringe to the surviving forest (tree species, alpine juniper and some willows), as at Creag Fhiaclach, in the Cairngorms.

Table 2. Comparison of Horsfield & Thompson categories (1997) with NVC (Rodwell, 1991)

Scrub category	NVC types included
Alpine Willow Scrub	W20 *Salix lapponum-Luzula sylvatica* scrub CG 14 *Dryas octopetala-Silene acaulis* ledge community U15 *Saxifraga aizoides-Alchemilla glabra* grassland U16 *Luzula sylvatica- Vaccinium myrtillus* tall herb community U17 *Luzula sylvatica-Geum rivale* tall herb community M11 *Carex demissa-Saxifraga aizoides* mire
Alpine Juniper Scrub	W19 *Juniperus communis* spp *communis-Oxalis acetosella* scrub H15 *Calluna vulgaris-Juniperus communis* spp *alpina* heath
Dwarf Birch Scrub	M19b *Calluna vulgaris-Eriophorum vaginatum,* mire *Empetrum nigrum* sub community M19ciii C *vulgaris-E vaginatum* mire *Vaccinium vitis-idaea-Hylocomium splendens* sub community *Betula nana* variant M17 *Scirpus cespitosa-Eriophorum vaginatum* blanket mire MIS *Scirpus cespitosa-Erica tetralix* wet heath

Values of scrub

Most of the tall shrubs already mentioned are nationally scarce (occurring in less than 100 10km squares). *Salix lanata,* the least common, is listed as vulnerable in the Red Data Book for threatened plants and it now has a Species Action Plan (SAP) under the UK BAP (Anon, 1994). Juniper also has a SAP. The *Betula nana* variant of the blanket bog, NVC community M 19ciii, forms part of the priority active blanket bog habitat in Annex 1 of the Habitats Directive (The Council of European Communities, 1992).

A healthy forest spreading from valley to high mountain has an intrinsic appeal and would signify the realisation of an aesthetic ideal of ecological potential. This should be reason enough but there are many others for the restoration of montane scrub and natural treelines. It is likely that the nature of the scrub would be variable, but normally broken and mosaic in structure. This structure fits exactly with the requirements of the priority Biodiversity Action Plan species, *Tetrao tetrix* L. (Black Grouse), which is currently in serious decline as a result of habitat loss, and with *Saxicola rubetra* L. (Whinchat), which is currently causing conservation concern (Mortimer *et al.* 2000*).* There may be enough attraction for occasional visiting birds, such as the *Luscinia svecica* L. (Bluethroat), to establish breeding populations, while *Turdus iliacus* L. (Redwing). T. *pilaris* L. (Fieldfare) and *Fringilla montifringilla* L. (Bramblings) may develop more stable breeding populations (Scott, 2000). Raptors should not suffer from the patchy distribution of scrub and might benefit from the increase in prey.

Bland, Entwhistle and Horsfield (1997) concluded that despite incomplete information on the invertebrate fauna, current knowledge indicates the conservation importance of montane scrub for a number of groups. They advised that action was urgently required to halt the fragmentation of the remaining scrub in order to avoid impoverishment of the associated fauna. The shelter and nutrient recycling of scrub plants plays an important role for other plants, mainly tall herbs, some of which, such as the very rare *Cicerbita alpina* (L.) Wallr. (Alpine Blue sow-thistle). are currently endangered due to the continuing levels of grazing and loss of suitable habitat.

Visually, the restoration of natural treelines and montane scrub would add diversity to the hill landscape. Having succeeded in returning forests to the valleys, there is now an opportunity to soften the normally abrupt upper margin, providing shelter for the growing high forests below. This more natural appearance will provide a more diverse experience for walkers making their way to the hills. In a landscape substantially bare of vegetation above half a metre in height a broken canopy between one and three metres tall would provide considerable shelter, to walkers as well as deer and sheep, during bad weather.

Restoration issues

MacKenzie (2000) recently reported on the collation of all existing records for low alpine, subalpine and coastal scrub communities in Scotland. He reports a variable level of information available for scrub sites, ranging from presence or absence in a ten-kilometre square to a full site description with a map. The majority of records fall in between, reporting presence or absence for a four or six figure ordnance survey grid reference, information which does not allow any assessment of population trends or the viability of individual communities. Despite the variation in information the data set provides a useful tool for initial work to prioritise restoration activity. It also indicates where there is a need for further field work to increase knowledge of the scrub communities in order to better focus resources.

A recent condition survey (Marriott, 1994) of thirteen of the remaining thirty-two sites for *Salix lanata* showed that in at least three sites it was ecologically extinct, having only one sex present, and that the small number of plants surviving at several others brought into question their viability. A similar survey for S. *lapponum* (Ross, 1996) failed to relocate the plant at four out of fifteen sites in the sample. Data for B. *nana* by MacKenzie (2000) shows that a number of sites, particularly in the west, have not been recorded since the 1970's. This growing body of evidence suggests that these tall shrub communities are under continuing pressure and that action is urgently required to halt their demise.

From the start the principle method of establishing forest areas employed by the Forestry Commission has been through planting and the exclusion of larger herbivores by fencing. This practise is increasingly being challenged in projects where the aim is to generate natural heritage benefits. Fencing is a barrier to movements of animals, and man, and is a danger to the native woodland grouse *Tetrao tetrix* L. (Black Grouse) and *Tetrao urogallus* L. (Capercaille) both of which are in serious decline. However, the former particularly, could benefit substantially from an expansion of the scrub habitats that border high forest. This illustrates the dilemma facing restorative efforts within the context of overgrazing when culling is politically contentious.

The Royal Society for the Protection of Birds (RSPB), and the Government advisers on Natural Heritage, Scottish Natural Heritage (SNH), have recently regenerated areas of native birch and pine forest without the use of fences, relying on a significantly reduced deer population achieved through culling. However, many montane scrub populations exist in high calcareous valleys where the ground vegetation provides high quality browse. The current imbalance between the size of the remnant plant populations and the numbers of deer is such that it is unclear whether it is possible to restore these scrub communities in the presence of any deer.

Demonstration fencing undertaken through the MSR Project has raised questions about the practicality of fencing inside high mountain valleys to protect plants growing on unstable slopes. Very high levels of fence maintenance were required to mend severe damage each successive winter, even when the wires were removed over the winter period. The resource requirements for such action are beyond the commitment of a private estate and the current levels of government incentive, to be promoted as a serious solution.

The classic site for tall mountain willows is at the top of an inaccessible cliff, on the wall of a steep hanging valley, or on wet, unstable slopes, where they might be reached they show signs of browsing (Marriott, 1997). They grow at their most lush along inaccessible stream gorges or on broad cliff ledges In such situations they are exposed to rockfall, landslip, avalanche and ice plucking and there is annual evidence of the toll this takes on the communities at the sites visited regularly. It is also likely that these 'typical' montane scrub habitats are only the marginal sites that have been left since an increase in grazing following the introduction of sheep to the hills in the nineteenth century (Mardon 1990), has eradicated these communities from more suitable sites.

Both willows and juniper are dioecious. There are a number of colonies of both types which are single sexed and could be considered ecologically extinct. When both sexes are present casual observation suggest that it is important that they are within 50m of each other (Marriott, 1997) for effective pollination by their main pollinators - bumblebees. For many colonies there is no information available on which to base an assessment of long term viability.

As interest in indigenous native woodlands has grown, there has been greater understanding of the role of geographical adaptation in different genotypes of the same tree species in Scotland, work on *Pinus sylvestris* (Scots pine) has shown clear differences between west and east coast genotypes (Kinloch *et al*., 1986). No work of this nature has been undertaken on tall mountain shrubs, in Scotland, with the consequence that there is no clear information on the best ways to restore genetically isolated but ecologically extinct communities.

Financial assistance available to land managers in Scotland comes in three distinct forms, Agricultural subsidy for farming and crofting in the uplands has always been a form of social subsidy, but it has been focused on increasing agricultural production efficiency. By contrast, the forestry subsidy is a contribution to costs, historically as an incentive for the development of a timber resource. This emphasis has changed recently to include the protection and expansion of semi-natural woodlands for bio-diversity reasons. SNH disburse grants for activities that benefit the natural heritage of Scotland. However, their grants are small and increasingly tied to habitats of international importance and sites designated through Natura 2000. They are also partitioned from forestry grants to avoid double funding.

The down turn in agriculture and the increasing realisation that the main asset of the north of Scotland is its natural heritage have highlighted the inadequacies of current financial incentives for encouraging holistic management proposals from land managers.

Conclusions and next steps

Greater understanding of the benefits provided by a natural treeline and scrub zone are required before cogent arguments can be made in favour of grants for integrating this habitat with modified current uses. The necessary pressure required to deliver this will come from increased public awareness and, hence support. Effort to address this issue has been made through the promotional booklet called 'Montane Scrub' (Scott, 2000) and the report by MacKenzie (2000) goes a long way to clarify the state of knowledge and understanding of scrub. In spring 2001, a conference plans to bring to a broad audience a number of guidance notes summarising current best practise in management and restoration of scrub for debate and development of consensus on the way ahead.

The restoration of montane scrub is the logical next step following restoration of woodland within the forest zone. However, there is a need for better information about the existing communities in order to halt their demise and prioritise action for restoration. As emphasis moves away from large numbers of her-bivores, both sheep and deer, there is scope to develop montane scrub to provide shelter and additional foods as well as for biodiversity benefit. Recent information predicting woodland cover potential shows that on suitable ground in the Cairngorms high altitude scrub cover could be as much as forty-eight percent compared to the current cover of just under nine percent. An initial target to double this current area in order to stabilise the existing communities is wholly reasonable.

In parallel with moves to secure the existing communities there is a need to substantially improve our understanding of tall shrub plants and their tolerance to browsing. Willows are adapted to browsing, but what is the relationship between the size of plants and colonies and grazing pressure? Another equally important area of research is the relative importance of seed production and asexual propagation, and best practise in achieving both. The answers to these questions need to be related to use of hill land by other interests to determine how scrub recovery can be integrated. But it is important that every current opportunity is taken to promote and undertake restoration, without waiting for the outcome of research. To allow this action we urgently need to find ways to make shrub plants visible within the current site survey methods that use NVC, and to properly reward management for biodiversity. Cross-sectoral compliance would need to be a key feature of such incentive schemes, with stewardship seen as the management focus. To facilitate such management initial best practise guidance has been produced through consultation with a wide range of upland land use interests.

Postscript

Highland Birchwoods is a charitable company limited by guarantee concerned with the role of forestry, and particularly native woodland, in rural development. Our underlying principle is that local access to local resources can provide the basis of a diverse rural economy contributing to long term sustainable employment and forest habitats. Consequently our work focuses on the research, development and promotion of good practise in management and use of forest areas at a local level.

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PAUL J. MITCHELL-BANKS

The Muskwa-Kechika Resource Management Area

Innovative Integrated Resource Management in Northeast British Columbia, Canada

SAMANTEKT
Markmiðin með stofnun Muskwa-Kechika verndarsvæðisins í Norð-austur-Bresku Kólumbíu í Kanada árið 1997 voru að vernda til frambúðar óbyggðareinkenni svæðisins, fjölbreytni dýralífs og búsvæði þess og um leið leyfa nýtingu auðlinda á hluta svæðisins, s.s. til útivistar, veiða, skógarnytja og jarðefnavinnslu. Verndarsvæðið nær yfir 6,3 milljónir ha, sem er á stærð við Írland, í norðanverðum Klettafjöllum og á Sléttunum miklu. Aðferðir sem viðhafðar eru við stjórnun svæðisins eiga að vera fyrirmynd í að ná bæði náttúrufarslegri og efnahagslegri sjálfbærni.

Muskwa-Kechika verndarsvæðið er meðal mikilvægustu óbyggða-svæða í Norður-Ameríku. Þar eru víðáttumiklir skógar, glæsilegar jarð-myndanir, ár og vötn, fossar og hverir, fjalllendi og votlendi. Innan svæðisins eru miklar olíu- og gaslindir og er orkuiðnaðurinn mikilvægur vinnuveitandi. Verðmætir skógar þekja stóran hluta svæðisins og er skógariðnaður einnig mikilvægur. Í greininni er fjallað um sögu og stjórnun svæðisins og ýmsa þá erfiðleika sem við er að glíma í því sambandi.

the Northern Rockies and Great Plains in northeastern British Columbia. This area, which is approximately the size of Ireland, is comprised of approximately 1/4 parks and 3/4 special management areas, where resource development will be undertaken with environmentally sensitive management. The management model is intended to establish a world standard for environmental and economic stability.

The Muskwa-Kechika Management Area is one of the most significant wilderness areas in North America with extensive forests, spectacular geological formations, lakes, rivers, waterfalls and hotsprings, subalpine and alpine areas and major wetlands. It is home to a huge variety of wilderness and wildlife. The Muskwa-Kechika area encompasses large oil and gas reserves, and the energy sector is a major employer in the area. The central and western areas of the Muskwa-Kechika are high in metallic and non-metallic resources. Portions of the Muskwa-Kechika Management Area have high timber values, with over 40% of Fort Nelson's (one of BC's most northerly communities) economy based on the forest sector.

Introduction

Please note that in November 2000, the Muskwa-Kechika Management Area was increased in size by 50% and $1 million additional funds provided to the trust fund. This paper reflects those changes.

The management intent of the Muskwa-Kechika Management Area, established in 1997, is to maintain in perpetuity the wilderness quality, and the diversity and abundance of wildlife and the ecosystems on which it depends, while allowing resource development and use in parts of the area designated for those purposes including recreation, hunting, timber harvesting, mineral exploration and mining, oil and gas exploration and development. The area encompasses more than 6.3 million hectares of

British Columbia's history of resource conflicts

British Columbia has had five forestry-related commissions over the last century, all of which were established to address the public's concerns about whether forestry was being carried out in a responsible manner and fears about a perceived shrinking forestry landbase (Mitchell-Banks 1999) Historically, British

Columbia has been a supplier of lumber, pulp and paper, minerals and coal, oil and gas and fish - essentially a Staples economy.

The book *Our Common Future* (World Commission on Environment and Development 1987) raised the concept of sustainable development and led to a widespread societal re-examination of whether we were living sustainably. Compounding the problem of a rapidly growing global population, were the challenges of technological change, globalised trade, cross-border investment and trade protection. All of these were occurring at a time of increasing resource management knowledge, changing social values and a slowly evolving political position to supporting the concept of sustainable development.

With these and other issues, such as unsettled native land claims, British Columbia saw an increase in both the scale and scope of resource-based conflict, with a 'war in the woods' declared, in which the forestry sector found itself at odds with a number of First Nations, environmental and other organisations.

The Peel Commission and a new approach

Growing public concern over the state of forests, the concentration of harvesting rights and processing facilities in the hands of the major forest companies and a move by the government in 1989 to convert Forest Licenses (volume-based tenures) into Tree Farm Licenses (area-based tenures) led to a strong public backlash. As a result: the government established the Forest Resource Commission in 1989, also known as the Peel Commission, which was intended to be permanent, but only lasted for three years (Mitchell-Banks 1999).

The Peel Commission managed to address a number of policy and legislation issues, and recommended a number of actions, including: integrated land management for all users: an increased level of co-ordinated land use planning: the need for public participation and local input in joint management decisions; and wilderness (Peel 1991). The Land and Resource Management Plan and Protected Areas Strategy can be attributed to recommendations stemming from this commission.

Land and Resource Management Plans

Across the province, an ongoing series of LRMPs is being undertaken. The LRMP boundaries have been set to coincide with those of the forest districts - and are therefore administrative and not necessarily determined by physical or biogeographic features. The intent of the LRMPs is to determine land-use, incorporating the participation of a number of representative stakeholders such as forestry, mining, agriculture, oil and gas, tourism, the business sector, labour, local government, environmental and other special interest groups as well as First Nations governments (Land Use Coordination Office 2000a). The provincial government then reviews and either completely accepts the submitted version or agrees to an amended plan.

Protected Areas Strategy

British Columbia chose a 12% target (total landbase) to establish protected areas, the figure driven by the World Commission on Environment and Development's (also known as the Brundtland Commission) choice of this level of protection. Protected areas are made up of land and freshwater or marine areas that are set aside to protect the provinces diverse natural, cultural heritage and recreational values. Protected areas are unalienable: the land and resources may not be sold. They are also areas in which no industrial extraction or development is permitted. No mining, logging, hydro dams, or oil and gas development will occur within protected areas (Land Use Coordination Office 1998).

The November 2000 approval of the Mackenzie LRMP led to the 12% target being exceeded (Land Use Coordination Office 2000b), and there are a number of LRMPs underway or yet to be started.

The Muskwa-Kechika Management Area

The M-KMA can be considered a 'child' of three LRMPs: Fort Nelson LRMP covering 9.8 million ha (October 1997); Fort St John LRMP covering 4.6 million ha (October 1997); and the Mackenzie LRMP covering 6.4 million ha (November 2000). Each of these three LRMP processes essentially carved areas of special significance that were in turn amalgamated to create the M-KMA (Land Use Coordination Office 1997a, 1997b, 2000c).

The 6.3 million ha Muskwa-Kechika Management Area is unique within Canada and indeed the world. It is an area of incredible beauty that has been inhabited by First Nations for millennia and has been the home, workplace and recreational area for local residents and international visitors for over a century. The M-KMA is one of the few remaining large, intact and almost unroaded wilderness areas south of the 60th parallel. It supports a diverse number of large mammals including moose, elk, mule deer, whitetail deer, caribou, plains bison, mountain sheep, mountain goat, wolves, black bears and grizzly bears in population densities of global importance. Few places in the world match the natural features of the M-KMA in terms of species groupings, remoteness and minimal development. The area is also well endowed with rich energy and mineral resources. In general, oil and gas reserves dominate the eastern portion of the area while a variety of metallic and non-metallic resources can be found in the central and western portions of the area. Valuable timber resources are also present in the southern portion of the area (Land Use Coordination Office 1997b).

The 1997 Muskwa-Kechika Management Plan sets out some ambitious objectives to address the unique beauty, biodiversity, cultural importance and resource wealth within the M-KMA, specifying that the management intent is to ensure that wilderness characteristics, wildlife and its habitat are maintained over time while allowing resource development and use, including recreation, hunting, timber harvesting, mineral exploration and mining, oil and gas exploration and development. The integration of management activities especially related to the planning and development of road accesses within the area is central to achieving this intent. The long-term objective is to return lands to their natural state, as much as possible, as development activities are completed (Land Use Coordination Office 1 997b) (Figure 1).

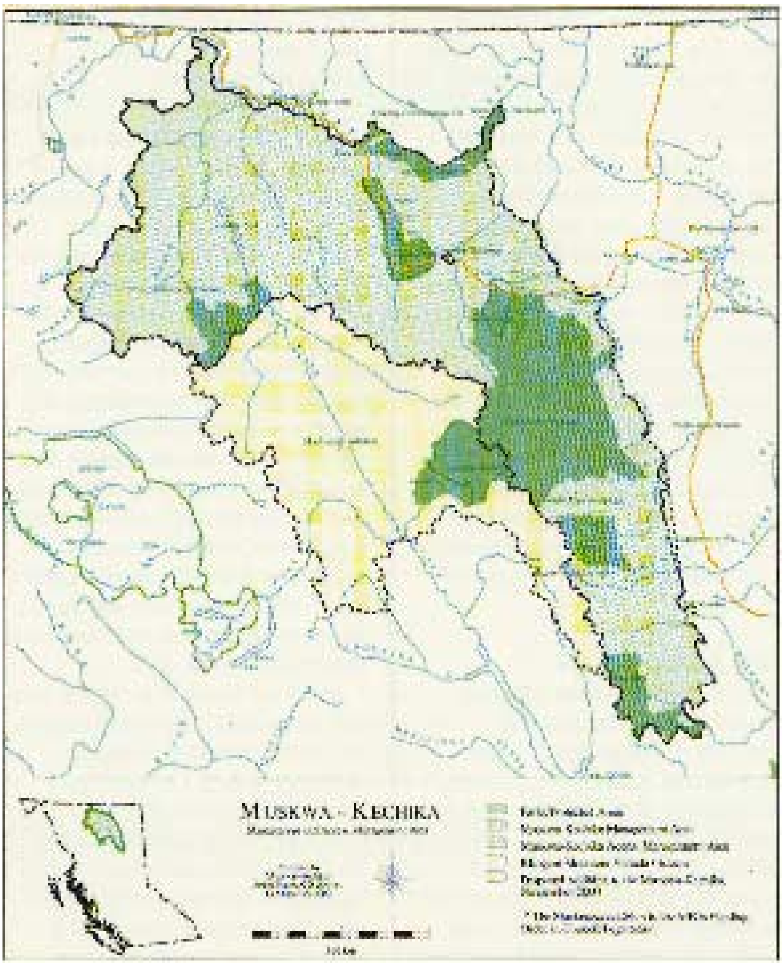

Figure 1. Location and Principle Features of Muskwa-Kechika Management Area.

Pressures in the M-KMA

Of all the activities within the M—KMA, the oil and gas sector is currently the most active and will likely create the greatest management challenges. With the recent increases in oil and gas prices, there is renewed interest in exploration and development, and this has led to a sharp increase in the number of seismic, drilling, facilities, and pipeline applications (Oil and Gas Commission 1999). The oil and gas rich Western Canada Basin extends west into the M-KMA. While to date the majority of the oil and gas activity is outside of the M-KMA boundaries, given the high prices, there is increasing pressure from industry and a desire by government to complete the pre-tenure planning within the M-KMA and thus open planned areas to oil and gas development. One of the oil and gas exploration initiatives that received a high degree of review and discussion occurred at Chicken Creek in the Upper Sikanni area. This is an important wildlife area and particular care is being paid to monitor any impacts.

Whereas the forest sector is one of the provinces largest industries, the Muskwa-Kechika Management Area is unique, in

Figure 2. Guide Outfitter camp in the Muskwa-Kechika Management Area.

that timber resources are relatively limited (Land Use Coordination Office 1997c). There is long-term planning for limited forestry development, with considerations such as road development and costs, haulage distances, stand size, density and piece-size all limiting the development potential. It is possible that forestry development will be closely associated with the oil and gas sector, taking advantage of roads approved for oil and gas exploration and development. In the near future, it is likely that forestry will initially focus on promising areas located at the south end of the M-KMA.

The M-KMA has important mineral resource potential supported by a mineral occurrence database, existing tenure and exploration and development activity. Historically the area has received limited exploration, but there is significant opportunity for mining (Land Use Coordination Office 1997d).

Trapping and guide-outfitting are historically important activities within the M-KMA (Figure 2). While the numbers of employees does not come close to the oil and gas sector, there is still a strong commitment through both legislation and ongoing management and planning to ensure that these activities are supported and have their needs considered.

Recreationalists, including hunters and fishers, and the back country tourism sector have historically accessed the area, with users from the local communities as well as others travelling great distances to take advantage of the vast wilderness.

Legislation and Planning in the M-KMA

The roots of the M-KMA lie within the three approved Land and Resource Management Plans. Specifically however, it was a 1997 Order-in-Council (where government ministers approve a decision without going to the legislature) that established the Muskwa-Kechika Management Plan (Province of British Columbia 1997). The following year, the government passed the Muskwa-Kechika Management Area Act. Both the Muskwa--Kechika Management Plan and the Muskwa-Kechika Management Area Act address the five required planning processes to be undertaken with the area, namely, Recreation Management Plan; Wildlife Management Plan; Oil and Gas Pre-tenure Plans: Parks Management Plans: and Landscape Unit Objectives (for forestry planning). What is unique about these plans is the requirement for multi-ministry sign-off, which assists in ensuring that planning is co-ordinated and addresses a broad range of issues.

M-K Advisory Board

The Muskwa-Kechika Advisory Board is appointed by the Premier of the province to provide advice on natural resource management in the area, and to identify suitable projects and proposals consistent with the purposes of the trust (Minister of Environment, Lands and Parks 1998). The current board consists of 22 members, including the chair (who is a member of the Legislature); seven First Nations representatives; three local government representatives; two members from the Oil and Gas sector; one mining sector representative; a forestry representative; one labour representative; two environmental representatives; one trapper guide member; a member of the BC Wildlife Federation; a back country tourism representative and the Muskwa-Kechika Program Manager (ex-officio position). Meetings are held a minimum of three times a year, with at least one of the meetings being held within the M-KMA to help orient the board members to the issues and to increase their awareness about the Muskwa-Kechika Management Area.

Muskwa-Kechika Trust Fund

A unique policy feature is the M--KMA trust fund, which has two primary purposes: 1) to support wildlife and wilderness resources of the M-KMA through research and integrated management of natural resource development; and 2) to maintain in perpetuity the diversity and abundance of wildlife and the ecosystems on which it depends throughout the management area. The trust fund is currently annually provided with $3 million Canadian as well as a project fund top-up allowance in which the government will match dollar for dollar contributions, to a maximum of $400,000.

Every fall there is a call for project proposals, which are submitted to the Muskwa-Kechika Advisory Board, subject to a number of review processes. Currently there are five project funding envelopes under the trust fund, namely: building an information base; supporting planning: improving manage-

Figure 3. Researchers with a sedated grizzly.

ment, advancing applied science; and promoting awareness and involvement. There is ongoing research with wildlife and habitat, particularly for certain species such as Grizzly, Moose, Elk and Stone Sheep (Figure 3).

Management Challenges in the M-KMA

There are numerous challenges in attempting to effectively manage the M-KMA. The most obvious one is the sheer size of the area at 6.3 million hectares. Access is extremely limited (also as directed by the LRMPs) with only a few roads, and trails that are accessed by horseback, snowmobile or all terrain vehicles. Government staff make extensive use of helicopter and jet-boat transport.

Along with the extreme distances are the extremes in temperature, with seasonal fluctuations of 80°C not uncommon. At - 40°, equipment is subject to heavy wear and it is trying on the staff as well, particularly when dealing with problems. All staff have emergency survival gear in our vehicles. I have personally experienced accidentally driving off a remote logging road with temperatures reaching -43°. It was quite a worrying experience and has increased my awareness of the challenges of the northern continental climate.

Another management challenge is the long distance (approximately 1,300 km by road, two hours by air) from the provincial capital for many of the senior government executives ultimately responsible for the success of the M-KMA. Extra care has to be taken to keep the 'southern' managers up to speed on the issues and actions being taken by the 'northern' statutory decision-makers. This can be frustrating for both 'southerners' who are more aware of the machinations within the legislature and the 'northerners' who are more aware of the local situation.

There is growing public awareness and level of expectations about what 'could' or 'should' occur within the M-KMA. It is difficult to ensure that everything that is planned, or simply decided upon at a political level, is effectively implemented. The M-KMA, being a new approach to planning and management, demands that the government staff, board members and public participants in the planning process attempt to address challenges with a set of 'fresh eyes' and often innovative approaches.

The final, and potentially greatest challenge, revolves around land claims based on both past and future treaties with First Nations. Planning and management is underway without any future certainty as to what lands may be awarded in the north and particularly in the Muskwa-Kechika Management Area.

Lessons learnt to date

There have been five major lessons learnt to date from the M-KMA initiative. The first lesson involves the need of obtaining adequate data and knowledge about the land, stemming not only from the 6.3 million ha size but also from the tremendous biodiversity, differences in physio-geography and the challenges of access to the area.

The second lesson is related to the first, but centres around the challenges of accurate and timely analysis and decision making. This involves a number of components including translating field data into a Geographic Information System (GIS), and devising adequate tools to verify, correct, analyse, manipulate and map the output. GIS staff are in high demand from both the government and private sectors, and we have lost a number of high quality staff as a result of this.

The third lesson is to obtain adequate funding for travel, sufficient staffing and equipment and resources to effectively manage the area, and to be able to proactively address anticipated developments, such as oil and gas development continuing to increase in both scale and scope. Hiring freezes and challenges in finding and retaining staff, particularly those in the GIS area, compound this problem.

Politics and agendas are the fourth lesson, and are an inherent part of the Muskwa-Kechika Management Area initiative. Politicians, responding to lobbying, sometimes make decisions without consulting with government staff and without any appreciation of the existing situation or resources available. The M-K Advisory Board is composed of members from a broad range of constituencies and each brings the expectations and aspirations of their sectors to Board discussions. Government managers and staff also have the mandate of their ministries to fulfill, which can result in clashes between the ministries because of their conflicting objectives. One of the most challenging aspects of the Muskwa-Kechika Program Manager's job is to champion the Muskwa-Kechika Management Area initiative and to serve as a liaison between the various groups and promote effective communication, 'buying' into a common vision and co-operation.

Roles and responsibilities are the fifth major lesson learnt from this initiative. Funding has grown increasingly scarce over the last decade, and the trust fund is drawing increasing attention from both within and without government. In many ways, it is the trust fund that can potentially serve the greatest role in ensuring that the M-KMA is successful, and there needs to be a healthy appreciation between the Muskwa-Kechika Advisory Board and government staff in how to best apply the fund to complement existing government responsibilities and initiatives. The trust fund is there to advance the M-KMA with a view to maintaining its unique features while also permitting industrial development over three-quarters of the area. This is a daunting, but not insurmountable challenge, requiring all parties involved to assume their roles and co-operate to achieve not only their individual responsibilities but also those of the group as a whole.

Acknowledgements
I would like to thank the Iceland Forest Service, and particularly Throstur Eysteinsson and Karl Gunnarson for their wonderful hospitality and an incredible conference and related forestry trips. I would also like to thank the provincial government for permitting me to attend the workshop and to acknowledge that all comments and views expressed within this paper are those of the author and do not necessarily reflect the official views of the government of British Columbia or the Muskwa-Kechika Advisory Board.

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JØRGEN AMDAM

Local Confidence and Institutional Capacity Building

- Forestry on the West Coast of Norway as an Example

SAMANTEKT
Á árunum fyrir og eftir seinni heimsstyrjöld var mikið átak í nýskógrækt í Vestur-Noregi, sem byggðist einkum á gróðursetningu rauðgrenis á bújörðum í einkaeign. Þetta var fyrirmynd Héraðsskóga og annarra landshlutabundinna skógræktarverkefna á Íslandi og hefur þessi grein því verulegt spágildi fyrir okkur. Nú eru greniskógarnir í Vestur-Noregi, sem yfirleitt hafa vaxið mjög vel, margir komnir í þá stærð að verðmæti timburs úr þeim er í hámarki og fer dalandi héðan í frá, en aðeins hluti skógareigenda er að fella skóginn og selja timbur. Hins vegar þarf skógariðnaðurinn á hráefninu að halda. Hvað veldur og hvernig er hægt að hvetja skógareigendur til dáða? Með rannsóknum þar sem m.a. var rætt við skógareigendur kom í ljós að ástæður fyrir skorti á skógarnytjum eru flóknar og tengjast landeigendunum sjálfum, efnahagslegu umhverfi og skorti á hefðum og þekkingu, t.d. varðandi timbursölu. Skógareigendur falla í fjóra flokka: 1) virkir í nytjum og sölu, 2) áhugasamir um skógrækt og virkir að hluta, 3) óvirkir en með möguleika á að verða virkir og 4) óvirkir og án möguleika. Í ljós kom að skógareigendur búa yfir lítilli formlegri þekkingu á sviði skógfræði eða skógtækni og aðeins þeir áhugasömustu leita sér þekkingar. Þá vita margir skógareigendur ekki af tilvist stofnana, félaga og fyrirtækja sem fást við skógarnytjar. Niðurstaðan er að til þess að auka virkni skógareigenda þarf að 1) gera sér grein fyrir að flestir skógareigendur eru „hobbí“ skógarbændur og 2) að efling á fræðslu og ráðgjöf og þar með þeim stofnunum sem hana veita skiptir öllu máli.

Introduction

Can local confidence building and co-operation strengthen local communities and have a positive influence on local development of forest activities? Through quantitative and qualitative research including, among other things, interviews with forest owners, we have found that the causes for lack of timbering are complex and connected to the property owners themselves, to economic conditions, but also to a lack of tradition and knowledge of timbering and sale of that type of lumber (Amdam et al. 2000). We focused on status and development of knowledge resources, relational resources and mobilisation related to forestry. Because forestry usually is only the third most important income for forest owning households on the west coast of Norway, a lot of mobilisation is needed to increase activity. Some of the conclusions regarding institutional capacity building in forestry are discussed as an example on challenges facing local development and use of new resources.

Forestry on the Norwegian West Coast

Can active confidence building and co-operation actually lead to better local and regional use of forest resources? My example is from the west coast of Norway, where we have studied reasons for low logging activity, especially that of planted spruce (Amdam et al. 2000). Because of high precipitation and favourable growing conditions for spruce in western Norway, it is possible to achieve production four times higher in raw material for a given area, compared to pine, obviously an important motive for such activity. Since spruce is not native, it is imported from other parts of Europe and America that have approximately the same growing conditions as in western Norway, gradually leading to natural rejuvenation.

This process has lead to development of organisations and work methods which focus on motivating property owners to plant spruces in appropriate areas.

Today spruce that was planted before and just after World War II is beginning to become mature and must be harvested. The problem is that such logging is not happening to the extent necessary to avoid development of over mature stands and reduced economic value. What are the causes of this and what should be done in order to stimulate sustainable logging from the local economic point of view?

Forest ownership

In our study we found big differences in forest activity between local communities and farms with approximately the same natural conditions (Amdam et al. 2000). Understanding the situation and adaptation of households that own forests is essential for understanding causes for lack of logging and for being able to increase the level of logging. Through personal interviews with over 90 forest owners in 7 municipalities in Møre og Romsdal and Sogn og Fjordane, we have found that operators and households can be divided into four main groups (Amdam 1999b).

The commercially active. This includes households and farms where income from logging of forests means a good deal for the total household income; the household is actively interested in the forest, pursues active conservation and active logging, making sales in general through the forest owners' association. The intensity of forest use is often quite high, while less intensive farming (livestock for slaughter) is often pursued, and often in combination with income from outside the farm. In areas with few possibilities for work outside of farming, there is a more common combination of active live stock raising and forestry. Even if forestry is typically "male-dominated" in most areas, we have also found women with active interest in the forest in "forest-active peripheral areas" such as Tingvoll municipality. The forests belonging to commercially active households are often large compared to forests of other farms in the same area.

Forest-active. These farmers and households are actively interested in their forests, active with both conservation and harvesting, but mostly for their own use and for "friends" and acquaintances. They are often active users of local sawmills, but not very "commercially active" through the usual system of sales. They often have medium-sized milk production and the household often has an annual income from outside the farm. The income adaptation and the size of the forest are such that use of the forest will only yield a secondary income and a way to make use of "empty time" by exploiting resources that the household uses itself or that are sold to friends outside the vat system. Many of these can become commercially active in connection with increasing areas of spruce forests becoming ready for harvesting. Spruce is also sometimes seen as a "problem" because the forest must be logged before it starts losing its economic value, it isn’t "money in the bank" like pine can be.

Passive with potential. This is a large group comprising active farmers with often more than one work-year of milk production and with medium-sized to large forests. Younger households also often have income from outside the farm in the amount of at least one half work-year. What distinguishes this group from the first two is that they do not have an active attitude toward the forest. They are seldom in the forest and find it difficult to carry out forest operations "between farm chores" even though they own usable machines and forest equipment. As one responded: "If I have to choose between drinking a cup of coffee with the wife and driving into the forest and cutting down a tree or two before the next chore that has to be done on the farm, it's usually coffee." The threshold for these individuals becoming commercially active foresters is far higher than for the first two groups, both connected to attitudes, knowledge and the possibilities associated with available time. However, collaboration with other operators, both on the side of livestock and forestry operations, can possibly bring changes.

Passive with little personal potential. This is the largest group we have studied in terms of the number of households in the rural communities and is also a strongly variable group. One sub-group are the recently retired, often older bachelors on small and medium-sized farms who have little meat or milk production, just enough to "get by". It also includes households that own a small farm with little forest and get most of their income from outside of the farm. The farm is a residence but they have little knowledge and take little active action with respect to their forests, they hardly even know "where it is." They consider it unlikely that they will one day buy equipment or hire competent help to operate the forest. The forest is too small for that and it is too dangerous to work there, outside of removing wood for private use that is. Forest owners living outside of the community belong to this group. In order to set in motion activity in the forests belonging to this group, it must be done in other ways than by helping the group itself to become active.

In our quantitative study based on a questionnaire to 15% of all forest owners on the west coast who have sold timber the last 20 years (52% answered, see Amdam et al. 2000) we found the following situation (table 1). The group «Forest active» is divided into two since some of them sell some timber. This grouping of forest owners is based on answers to two questions "I have great interest in forestry" and "Do you expect (plan) to log timber for sale during the coming season?" (Scale 1 no - 6 yes). The criteria for being commercially active are high interest in forestry and plans for logging (answer 5 and 6 on both questions), while the forest active have high interested in forestry (5 and 6) but low probability for logging (1-3). The forest active with sale answered that logging was probable (4-6), but they were not highly interested in forestry (3 and 4). The group passive with potential is interested in forestry to some extent (3 and 4), but has no plans for logging for sale (1- 3). The group passive with little personal potential is not interested in forestry (1 and 2). As expected the active forest owners have bigger forests then the passive. (We have reasons to believe that the group passive with little personal potential and the other passive groups are underrepresented due to not answering our questionnaire, see Amdam et al. 2000).

Very little of the forest on the west coast of Norway is owned by people not living in the local community (under 10% of our responders). Activity in forestry is closely connected to activity in agriculture with the majority of forest owners selling timber commercially also active in agriculture (table 2). Very few however, have forestry as a major income. Only 3% of all forest owners on the West Coast earn more than 20% of household income from forestry, 7% between 11 and 20% and 12% between 6 and 10%. 78% of households get less than 5% of their income from forestry. Of all the responders 48% had agriculture and forestry as main income, 20% manufacturing industries, 22% services and 10% other main incomes (pensions etc.). In general the division into five groups as in table 2 also functioned as a ranging of forest activity where the commercially active forest owner had highest activity and the passive without potential had lowest regarding own forest work, plan for forest use and activity, equipment for forestry, planting and cultivation, sale of timber and wood, public support for forest activities like road building and participation in local forest owner organisations.

Table 1. Forest ownership on the West Coast of Norway.

Type of forest ownership	% of	% of forest area	Average forest area per forest owner
Passive with little personal potential	12	8	26,3
Passive with potential	30	24	33,3
Forest active	23	23	43,1
Forest active, sale	7	9	51,3
The commercially active	16	26	64,6
No answer:	12	10	35,9
Total:	100 (N=975)	100	41,4

Table 2. Activity in agriculture by group of forest owners.

	Agriculture as: Main household income	Part income	No agriculture income	Sum forest	(N)
Commercial active	63%	23%	14%	100%	164
Forest active, sale	58%	19%	22%	100%	72
Forest active	49%	26%	25%	100%	224
Passive with potential	43%	30%	27%	100%	327
Passive without potential	39%	23%	38%	100%	145
Sum:	49%	26%	25%	100%	

Institutional capacity-building

These challenges regarding development of forestry on the west coast of Norway can be compared to the concept of institutional capacity building (Healey et al. 1994:4): "The notion of 'capacity-building' and 'institutional capacity building' are not new concepts. They have been used to highlight the need to build up individual capabilities (e.g. labour force skills, or entrepreneurial capacity), and those of public administrations. In the former case, the focus is on the institutions which help to develop such capabilities. In the latter case, the emphasis has been on the capacity of particular organisations. The new thinking about institutional capacity focuses on the webs of relations involved in urban governance, which interlink government organisations, those in the private sector and voluntary organisations and those who in any way get involved in governance, that is, in collective action. The term 'institution' is given a sociological meaning as a 'enduring feature' of social life giving 'solidity across time and space' (Giddens 1984 p. 24), that is, it extends beyond formal organisations. to encompass cultural patterns (such as kinship relations, religious life, other 'moral communities' and informal civic associations of all kinds)."

To avoid the currently confused and broad use of the term "social capital", Healey et al (1999) use the term "institutional capital" which includes knowledge resources, relational resources and mobilisation capacity, the two first leading to the third. This model describes in a structured way the challenges discussed above facing local institutions that try both to develop local confidence and also to find local solutions to planning and development problems. We used this model to analyse challenges facing forestry on the west coast of Norway (Amdam et al. 2000). We also used perspectives from confidence building, local planning and institutional capacity building to develop strategies for change (Amdam 1992, 1995, 2000).

Knowledge resources

Only 42% of responding forest owners were of the opinion that they have enough knowledge needed for active forestry, highest (74%) among commercially active, lowest among passive without potential (13%) (table 3).

Only 3% of forest owners had a formal education in forestry and 9% had formal agriculture education and training. Between 74% (commercially active) and 96% (passive without potential) had no agriculture or forestry education at all! When asked about interest in advice, 54% answered that they would like more (table 4).

In our study we found that the commercially active forest owners had a higher degree of formal and tacit knowledge related to forestry then other groups and this knowledge was closely connected to our classification (table 3). Knowledge resources are of course related to formal education, but formal education related to forestry is very low on the west coast. Tacit knowledge learned from parents, from self-learning activity and traditions etc. seems to be more important. The active groups, especially the commercially active, are really interested in forestry. They "talk" forestry with other active forest owners, they are interested in local production based on timber, and they are interested in cultivating their forests.

On the other hand there is high variation in response regarding collective activities such as local traditions for forestry, organisational activities, co-operation etc. This is often explained as "Community X and/or farm Y having a strong tradition for forestry".

In general, the study showed that the knowledge resource related to forestry was very low

Table 3 Question: I have enough knowledge to be active in forestry.

	Passive without potential	Passive with potential	Forest active	Forest active, sale	Commercially active	West Coast
No (1 ,2)	48%	23%	7%	9%	4%	18%
Both/and (3,4)	40%	45%	40%	50%	23%	39%
Yes (5,6)	13%	33%	53%	41%	74%	42%
I alt	100%	100%	100%	100%	100%	100%

Table 4. Question: I have no need for advice in forestry.

	Passive without potential	Passive with potential	Forest active	Forest active, sale	Commercially active	Total West Coast
Disagree	37%	53%	58%	62%	57%	54%
Both/and	40%	35%	31 %	34%	31 %	34%
Agree	23%	12%	11%	4%	12%	13%
	100%	100%	100%	100%	100%	100%

among forest owners. Forestry is an activity for the highly motivated few. Most communities have low range, integration and openness regarding forestry, the forest doesn't "exist" as a proper income activity, it is not included in their frame of reference. Information is not meaningful and does not lead to comprehension of possibilities. To increase activity, the knowledge resources of all forest owners must be fundamentally changed into a more proactive attitude. On the other hand forestry is a marginal activity. The few forestry based knowledge resources, mostly tacit, are challenged by a higher formal education level outside forestry and agriculture in the communities, and the number of forest owners that are active in agriculture is steadily reduced as more and more find work in manufacturing industries and services.

Relational resources

Our findings are that the relational capital of west coast forestry is very low (Amdam et al. 2000). There are active networks between the commercially active forest owners, public forest advisers and forest owner organisations but these networks are not integrated into other local networks, they are regional or national "clubs of special interests". Since most active foresters are also active in agriculture production, one should expect an integration of these networks, but this is very seldom the situation. The public organisations and institutions dealing with forestry were mostly imported from the eastern part of Norway where forestry is important and where properties are rather big. Activities like advice, agriculture and forest planning are not integrated and education is separated at almost all levels. Agriculture is seldom spoken about in forest networks, and vice versa, in spite of being populated by the same land owners.

In local public planning, agriculture is much more important than forestry. When forestry is on the agenda, it is mostly as an activity perceived to be in conflict with environment and leisure interests. Very few speak about forestry in local communities (table 5).

In most communities, it is unusual to co-operate in forestry, with over 75% being of the opinion that the level of co-operation is too low (table 6). However, they do very little to change this situation.

The few forest-based networks are also under strong pressure. Alternative work, cut-backs in the number of forest advisers, reduction of active farmers, increasing age among forest owners etc., all make it difficult to increase activity in existing networks. To change this situation other networks must be activated - forestry must try to "occupy" and mobilise existing networks and to establish new ones that can mobilise new groups. Why not see forestry as a sport or leisure activity - anything that increases the focus on forestry can be of value in this situation. To talk forestry, especially about positive aspects, is maybe the single most important activity (Storper 1997). What we learned was that forest owners that had high income from forestry seldom spoke about their experience, while "amateurs" with bad experience from sale etc. spread this like "fire in dry grass".

Table 5. Statement: Forestry is often spoken about in the local community.

	Passive without potential	Passive with potential	Forest active	Forest active,	Commercially active	Total West Coast
Disagree strongly (1)	48%	21 %	18%	10%	10%	21 %
2	19%	33%	22%	31 %	17%	25%
3	14%	25%	23%	25%	24%	23%
4	12%	16%	20%	25%	31 %	20%
5	4%	5 %	12%	8 %	14%	8%
Agree strongly (6)	3 %	1%	6%	1 %	3 %	3 %
	100%	100%	100%	100%	100%	100%

Table 6. Question: Is it usual to co-operate in forestry where you live?

	Passive without potential	Passive with potential	Forest active	Forest active, sale	Commercially active	Total West Coast
Yes	12%	19%	23%	27%	30%	21 %
No	62%	65%	67%	63%	64%	65%
Don't know	26%	16%	10%	II %	6%	14%
	100%	100%	100%	100%	1.00%	100%

Mobilisation capability

Low knowledge and relational capital leads to a situation where mobilisation capability is low or rather that the energy needed for mobilisation to a certain level is high. Only 40% of forest owners know that there are change agents locally that work to increase forest activity, public agents included (all communes have employees working to increase forest activities). On the other hand, our qualitative studies have shown that activities can increase a lot if active forest owners work proactively to motivate other interested but inactive forest owners and if the public advice system can coordinate and give support to forest activities like forest road building, stimulate co-operation in logging between owners etc.

Our recommendations to increase forest activities are to give maximum support to active forest owners and to proactive public employees and give them the role of change agents (Healey 1997, Stöhr 1990). But mobilisation activities must build on these facts:

1. Mobilisation activities must respect that most forest owners on the west coast are "hobby forest owners", forestry is not an important part of family income and can be so for very few. On the other hand there are still, in most communities, forest owners that are genuinely interested in their forest, that it is cultivated and/or who can be activated in forestry as a leisure activity.
2. Mobilisation activities must be accepted and respected as a natural and important part of activities in public and other forest organisations. Change agents must be respected and stimulated and forest organisations must recruit persons that have the personal abilities and interests needed to be change agents.

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ÍSFUGL

HÉRAÐSSKÓGAR

JOHAN BARSTAD

Forestry and the Challenges of Modern Society

SAMANTEKT
Ýmsar ógnir steðja að skógrækt sem atvinnugrein í dreifbýli í þróuðum löndum. Skógrækt og skógarnytjar eru ekki lengur einangraðar frá samfélaginu í heild og það eru skógareigendur ekki heldur. Samfara fólksfækkun í dreifbýli hafa skógrækt og úrvinnsluiðnaður sem byggist á skógarafurðum orðið minna staðbundin. Fyrirtæki hafa stækkað og staðbundnum störfum við skógarnytjar hefur fækkað á meðan störfum við þjónustu og stjórnsýslu hefur fjölgað. Ýmislegt hefur orðið til þess að skógareigendur eiga erfiðara en áður með að vinna í skógi, þ.á m. minnkandi vægi tekna af skógarnytjum í heimilistekjum, vinna beggja hjóna utan heimilis og aðrar kröfur á tíma fólks. Meðalskógareigandinn í Vestur-Noregi á skóg sem er innan við 30 ha að flatarmáli. Hann er karlmaður kominn yfir fimmtugt og kvæntur konu sem vinnur utan heimilis. Börnin eru flutt á mölina og með atvinnu þar. Skógarnytjar skapa lítinn hluta af heimilistekjum, á eftir vinnu utan heimilis og landbúnaðartekjum. Engu að síður líta margir á tekjur af skógi sem mikilvægar. Einnig segja skógareigendur að vinna í skógi sé mjög skemmtileg og gefandi, að hún líkist frekar fríi en vinnu.

Introduction

Forestry as a rural activity is facing many challenges. Besides traditional forestry related issues, such as species selection, forest growth, silviculture, timber prices and markets, there have for some time also been the issues raised by environmentalist NGO's, like WWF, and Greenpeace. Traditionally, forestry existed within its own segment, having little or no interference from or influence on other industries or general policy, and was not a focal point for people outside the forestry sector. Forestry today has become a more obvious part of society at large in a way it was not before, forestry no longer exists in isolation.

All over the globe, we can observe a decline in rural population, migration to the cities and a an embracing of the urban way of life. At the same time, forestry is losing its status as a locally based industry with fewer jobs in logging and silviculture, a more professional organisation with out-of-town based crews, and an increase in absentee ownership. At the same time the major forest companies are getting larger and more international than before.

In this paper, I will discuss some of the aspects of modern day life as it can be seen in urban areas, in rural areas and in the interface between them in most developed countries around the Globe. My focal point will be through our work on a study of western Norwegian forest owners, and the upstream production in a small region around the town of Ålesund in Norway.

To quote some numbers

Western Norway has more than 30.000 forest owners (only counting the ones with more than 25 ha total forest area). The average size of forest holdings is 41 ha, which is reduced to 29,5 ha if only the productive forest area is counted.

In our study of the western Norwegian forest owner, we constructed a forest-owner categorisation, dividing them into five categories, according to their expressed interest for forestry and their activity level (Amdam et al. 2000). (This study also included some owners with less than 25 ha forest area). Activity level correlates with size of forest area, the owners of smaller forest areas typically being less active (Table 1).

Table 1. Forest ownership on the West Coast of Norway

Type of forest ownership	Respondents	% of area	Average forest area
The commercially active	16 %	26 %	64,6 Ha
Forest active, sale	7 %	9 %	51,3 Ha
Forest active	23 %	23 %	43,1 Ha
Passive with potential	30 %	24 %	33,3 Ha
Passive without personal potential	12 %	8 %	26,3 Ha
No answer:	12 %	10 %	35,9 Ha
Total: N -975	100	100 %	414 Ha

Table 2. Forest owners categories and main source of income (1996)

	Agriculture is the households: main income	secondary income	No household income from agriculture	Sum forest owners (N)	
Commercial active	63 %	23 %	14 %	100 %	164
Forest active, sale	58 %	19 %	22 %	100 %	72
Forest active	49 %	26 %	25 %	100 %	224
Passive with potential	43 %	30 %	27 %	100 %	327
Passive without potential	39 %	23 %	38 %	100 %	145
Total:	49 %	26 %	25 %	100 %	932

Table 3. Forestry income in percentage of total household income in 1996

	Over 20%	16 to 20 %	11 to 15 %	6 to 10 %	1 to 5 %	None	Number of respondents	
Commercial active	10 %	18 %	10 %	24 %	27 %	11 %	157	18 %
Forest active, sale	3 %	5 %	5 %	34 %	40 %	12 %	73	8 %
Forest active	4 %	2 %	2 %	13 %	36 %	43 %	211	24 %
Passive with potential	0 %	1 %	1 %	9 %	36 %	53 %	315	35 %
Passive without potential	1 %	0 %	0 %	4 %	18 %	77 %	141	16%
Total	3 %	5 %	3 %	13 %	32 %	44 %	897	100 %

Absentee ownership is still low in this region (less than 10 % of total respondents), but judging from owners' age-structure and the interviews we made, this percentage will rise significantly when the present owners hand over to the next generation. In most cases where there had been a recent hand-over to the next generation, it was not to the oldest child, which would have been the traditional way of doing it, but typically to the youngest. When asked about the reason, it turned out that the youngest was often the one with the least good reasons not to take over, the older ones being well established with occupations and residence outside the farm.

Some 92 % of the respondents regarded their forests to be part of a farm, and activity level in forestry was closely connected to activity level in agriculture (Table 2). The majority of forest owners selling timber on the commercial market were at the same time active in agriculture, but still only a few had forestry as a major source of income. Dependency of the households on forest income is quite low (Table 3). Only 3 % of the respondents earn more than 20 % of household income from forestry, 7 % between 11 and 20 % and 12 % between 6 and 10 %. 78 % earns less than 5 % of household income from forestry.

Of all the respondents, 48 % stated agriculture (including forestry) as the main source of household income, 20 % the manufacturing industries, 22% services and 10% had their main income from other sources (pensions etc.).

The general trend in society is that jobs are decreasing in primary and secondary industries, and increasing in the tertiary sector; the service-sector. So in many ways, forestry is being marginalised in a marginalised sector

Challenges from modern society

In former times, rural societies in many ways could be described as more or less independent from the larger society. Jobs were locally based, migrational patterns generally were short-distanced and social life was centred upon the place where one lived. If industries had markets on the outside, these generally were considered stable and lasting. Today, rural areas in most respects are fully integrated into society at large. Jobs are no longer only found locally and internationalisation and the development of free market economy have resulted in a much more flexible commercial structure that operates according to the same economic reasoning wherever you are located. Regarding forestry this can be said to have resulted in a segmentation where we can identify and describe four major trends:

The pulp and paper sector has become global. What formerly were nationally based companies are today major actors on the global market For example, the Norwegian based “Norske Skog” was originally founded by forest owners, who still are major shareholders. With recent buy of NZ based Fletcher Challenge, it was argued that Norwegian forest owners ought to sell their shares and use profit to invest in local industries, "as Norske Skog no longer holds any importance for the local development".

Sawnwood production has become regional. Larger units, concentration on national and regional levels. This is also reflected in the restructuring of Forest Owners Associations into larger units. An adaptation to a more market-based system, reducing the linkages to local and rural societies.

Various niche-markets have emerged at the local level. These markets are usually too small to be economically interesting on the national level. Values might f.ex. acknowledging some special physical quality of the wood when used in a special context, but often they are based more on subjective opinion (local identification).

"Other" forest functions are being promoted. Environmental organisations have played a role in increased focus on the non-timber values of forests: beauty, scenery, recreation, biodiversity and sustainability, as well as other functions concerning possible usage of forest area for commercial activities, tourism, berry picking, mushrooms, etc.

Looking at the economic dimension, job structures have become "urbanized": from self-employment to wage earning and from pluriactivity to monoactivity. Rural communities were formerly dominated by various occupations in the primary sector such as agriculture, fisheries, forestry etc. Today, wage-earning economy dominates in rural societies, both in the former primary sector, where in farmers have become more or less governmental employees through various subsidies and grant schemes, but especially through the emergence of the welfare state with its multitude of occupations in public administration such as education, health care etc. This also calls for a range of services such as janitors, gardeners, cleaners etc. resulting in job opportunities formerly non-existent in rural areas. And, offering good wages and regular hours, this is often considered more attractive than the insecurity of being self-employed. The self-employed often had to rely on several jobs to make a living. Also, being tied up in farm-production meant that full-time occupation off-farm was impossible. The change from self-employment to wage-earning has thus been followed by a decrease in pluriactivity.

There has also been a general tendency towards agglomerations. This has been mentioned above regarding forestry, but it has been just as obvious in other sectors of production and in public administration. Furthermore, local ownership in many cases has been transformed to a more "professional" ownership by entering the stock-market and thus lessening the degree of local control and responsibility.

Regarding the rural population, the trend has generally been that there is an out-migration of the young people, resulting in an ageing rural society with a skewed gender-mix. Also, women entering the workforce has resulted in new household patterns.

This has resulted in some important changes in social structures. In households, the traditional great-families comprising several generations have changed via the core-family to the modern single-family of ten with less than two persons on average. Greater equality and new roles for women have resulted in new roles for men, from being master of his own time to being a part of the family-activities *("if I have to choose between working in the forest on a Saturday or driving my kids to the swimming-pool, I normally chose driving the kids")*. Society also poses new challenges. Participation in civic society is emerging and embraced by public authorities as well as local communities themselves (cynic view: get cheap labour to do public work, altruistic view: increase social sustainability).

Findings about forest owners

From our study, and from what we have seen in developed countries around the world, it is possible to draw up some characteristics of forest owners and their households.

The normal situation is to be a small-scale non-industrial private forest owner. The average productive forest area in western Norway was below 30 ha and in most European countries the average is far smaller. It is likely that the median size is far lower than the average, due to the fact that few very large holdings raise the average. Small holdings make continuous activity (self-activity) difficult, be it commercial or non-commercial.

He (the typical owner is a male), is in his late fifties, his children have left home and are living in the cities. They have jobs (typically low unemployment) and in many countries (such as Norway), the regulation of property transfer is in many ways a hindrance for the young generation to take over (costs, legal conditions concerning residential and production issues, especially in situations where forest is connected to a farm). As mentioned earlier, the general rule seems to be that it will be the sibling with the least weighty arguments not to take over who ends up with the farm/forest.

In Norway we found the owner typically to be married, with the spouse working off-farm almost at the same rate as women on average. Thus, forest income as part of the total household income is normally in third place or lower, typically close to zero%, with only a very few (10 %) of the most active farms earning as much as 20% of the household income from forestry The total income from farming is also relatively low compared to income from other sources, in terms of wages per hour. Still, many consider forest income to be important, as it represents one of the few possibilities for earning extra income on the farm. In such a situation where there is no alternative price for labour, the hours worked count little, the total amount counts more.

A sub-group worth mentioning is the young forest owner. He is also typically married and has young children. His spouse normally works full time off farm (public administration, health care, teaching etc.) The farmer himself also tends to have most of his income from off-farm work, and having forestry income down at the bottom of the scale. Given the demands of modern society, they both take part in bringing up the children, and this in many ways results in having little free time to do forestry work.

This can be illustrated by the situation in one municipality in the years after a hurricane hit Western Norway in 1992. This used to be one of the most forest-active municipalities in the county, one of the few with long and continuous traditions of forestry. Because of the increased supply of windthrown timber, this municipality, which only sustained minimal damaged, decided to postpone logging for two years. But when the two years had passed, and logging could commence, there were problems in reaching the old logging level for several reasons, but the more interesting was that during the two years, a local female entrepreneur had established a successful firm employing local women. So, when the husband was to go to work in the forest again, he found he no longer had the free time at his disposal since he had to contribute more on the domestic level while his spouse was out earning money. Thus an initiative positive to the local community proved difficult for local forestry.

Still, even though there are problems for the young forest owners, they do regard forestry as "the most pleasant part of their work". In fact, all owners state that the time spent in the forest is more alike to a holiday than to tedious work. As one put it: "... in the forest I have time to sit down, brew coffee over an open fire, admire the scenery and escape from the daily grind". Being a farmer in a developed country today is a stressful occupation. Thus we cannot overlook the importance of these therapeutic functions of forestry.

It may be correct to say that the forest owner household today is trapped in the "time-squeeze". Formerly being more on the outside of society at large with more of a say as to what to do and when to do it, the situation today is much more like that of urban dwellers. As time-slots are getting shorter, it will be increasingly difficult to use them in forestry activities. This in many ways is a type of work needing longer stretches of time to prepare equipment, travel to forest, do the work and finish up afterwards.

Another important group is the professional forest worker. The use of professional workers varies quite a lot across countries and regions, an important factor being the profitability of hiring outsiders as opposed to doing the work yourself. But there still are some trends to be seen. First, it seems there is, to an increasing degree, little or no connection between worker and locality. A professional crew will have to work a large area to make a living. Secondly, this implies that the benefits of using professionals to the local community are very small. Thirdly the generally low profitability in logging ensures that you have to work long, hard hours.

It is possible to discern an emerging pattern of forest workers similar to that of the crews working on oil-platforms at sea: you get in, work two or three weeks, then get out and recuperate for a period.

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LOTTA JAAKKOLA, MIKKO JOKINEN & TAPANI TASANEN

The present and the future of the timberline forests in Norway, Sweden and Finland:

Opinions of researchers and land use managers

SAMANTEKT
Rannsóknirnar sem hér er sagt frá fjalla um skoðanir sérfræðinga annars vegar og stjórnenda auðlindanýtingar hins vegar á framtíðarhorfum í sjálfbærri landnýtingu við skógarmörk í Norður-Noregi, Svíþjóð og Finnlandi. Á þessu svæði eru hreindýrahjarðmennska, skógarnytjar og ferðaþjónusta mikilvægustu atvinnugreinar nú. Sá munur kom fram að sérfræðingar litu á landnýtingu á svæðinu út frá fjölbreyttum möguleikum á meðan stjórnendur litu frekar á efnahagslegar hliðar nýtingar. Sérfræðingar og stjórnendur voru sammála um að framtíð ferðaþjónustu á svæðinu ætti að vera björt og að hefðbundin hreindýrahjarðmennska ætti framtíð fyrir sér ef tekið væri á ofbeitarvandanum. Stjórnendur í skógræktargeiranum töldu að skógarnytjar geti verið sjálfbærar og að hlýnandi veðurfar muni hjálpa þar til. Aðrir stjórnendur og sérfræðingar töldu það hæpið þar sem áhrif veðurfarsbreytinga gætu allt eins verið neikvæð fyrir vöxt skóga. Allir voru sammála um verndargildi svæðisins, bæði út frá náttúruvernd og verndun menningarþátta.

Background

Until recently, the socio-cultural aspect of the use of natural resources has remained underestimated. However, there is a great need for anthropological as well as ecological knowledge for sustainable management of nature to be further developed (Clark 1992). The way people define and conceptualise nature and its use differs and confrontation of different values and definitions can easily lead to environmental conflicts, which can have negative consequences for all stakeholders and create difficulties in management procedures (Jokinen 1998). The need to understand social and cultural conditions of management of timberline areas forms the background for this research undertaking.

This study focuses on timberline areas of Northern Scandinavia and Finland. There are various definitions for the term *timberline area,* but in this study such an area is defined as the transition zone between treeless tundra and areas with forest cover characterised by a continuous closed canopy. In Sweden, what are termed sub-montane forests, *fjällnära skogar,* covers an area of about 9 million ha, of which 1.6 million ha is in the category of productive timberland (Kankaanpää & Vormisto 1998). The areas defined as mountain forests, *vernskog* in Norway is estimated to amount to be approximately 23.5 million ha, which is about 20-25 % of Norway's total land area (NOU 1989). In Finland the protection forest zone, *jametsävyöhyke,* covers 3.15 million ha (Veijola 1998a).

For centuries, timberline forests have served as a source for firewood, timber, snags and wood for small-scale industrial use such as cooking of whale oil and salt production. In the 18th and 19th centuries, especially along the coastal areas of Northern Norway and Russia, logging and pasturing had a dramatic effect on the timberline forests. Inland, where population density was low, domestic cutting of wood had only local effect on the forests (Veijola 1998b). At the beginning of the 20th century, large scale exploitation of timberline forests lead to the passing of forest protection legislation, and since that time, use of the timberline forests has varied greatly between Sweden, Norway and Finland (Pohtila & Timonen 1980, Veijola 1998b).

Timberline areas have been important for reindeer husbandry for centuries and this livelihood continues to be one of the most important in these areas (Tasanen & Veijola 1995). The reconciliation of different land-use interests, especially forestry and reindeer husbandry, has in recent decades, given rise to heated debate (Gustavsson 1989).

In Finland, citizens of any EU country living in the reindeer husbandry area have the right to own reindeer, while in Norway and Sweden it is restricted, almost exclusively, to the Sami people (Helle 1995). The reindeer husbandry area covers approximately 36% of the total land area of Finland, and there are over 7,000 reindeer owners. For 800 of them, reindeer husbandry is the main livelihood (RKTL, Internet). The number of families earning their main livelihood from reindeer husbandry in Norway is about 650 and in Sweden 800 (Helle 1995). Recreational use of the timberline area plays an important role in creating jobs in the tourism industry, but at the same time tourism causes significant problems for the delicate ecology of these northern areas, where marks left by humans typically remain visible for a long time. The establishment of ski resorts, has also created land-use conflicts between the various interest groups.

Research problem

According to Clark (1992) there are distinct differences between the problems that science tries to tackle and the problems that managers face in natural resource management. Thus the goal of the present research is to gain understanding of different values, opinions and viewpoints of managers and researchers regarding the use of timberline resources. The research aims at answering the following questions.

- What is the timberline area and why it is important?
- What are the main land-use activities?
- What is the future of the timberline area and of the land-use activities?
- What are the things affecting the use?
- What are the possible threats to the timberline area?

The viewpoints of managers and researchers were compared and their implications for planning, policy development and management procedures, as well as for the sciences related to these activities analysed. Comparisons were conducted between Norway, Finland and Sweden, because of their common history, societal similarities, and similarities in the traditions of land-use and management of timberline areas. In this study, national and regional land managers and decision-makers are generally called managers.

Data collection and analysis methods

Data was collected by using semi-structured, face-to-face in-depth interviews, which are recommended in the case of expert interviews (Huberman et all 1994; Russell 1995). Experts i.e. managers representing the fields of nature conservation, reindeer husbandry and forestry, as well as researchers working in these fields, were chosen by using purposive and snowball-sampling methods. Respondents were from the Ministries of Agriculture and Forestry, Federations of Forest Owners, state forest services, various universities and research institutes, the Union of Reindeer Herders (in Finland), and World Wildlife Fund (WWF). Seventeen interviews were conducted in 1999, of which four were conducted in Norway, seven in Sweden and six in Finland. The interviews lasted for 25-60 minutes and were conducted in Swedish, Norwegian and Finnish. All the interviews were taped and afterwards transcribed. Analysis of the texts was a three step process in which the texts were divided among separate themes, re-organised and re-categorised. The resultant analysis units were used to form models. The process of creating the models may be divided into simplification of data and interpretation of results. In the simplification process, essential themes are searched for from the text. The analysis is actually a formation of general rules that are valid for all the data.

Results – Model of values

The models of values outline the factors, activities and values that belong to the timberline area and are therefore classified as image schematic models. As seen in the table 1, the researchers defined the timberline area as an area for multiple-use possibilities, i.e. it is pasture land, an area for tourism and recreation, a resource for non-timber forest products as well as a resource for household timber. Larger scale forestry is clearly restricted by the limitations set by climate, other forms of land-use and the importance of the protective role of these forests.

For managers, associations balanced between timber production and multiple-use possibilities and values (table 2).

Managers characterised the timberline area in terms of economical factors and criteria for forestry, which are both ultimately affected by climatic limitations. On the other hand, the importance of restricting land-use practises came out of the model.

The different values given to the timberline areas are presented in the tables 3 and 4. The foundation for ecological values of timberline areas is formed by essential ecosystem services such as fresh air and clean water, the ecological uniqueness that northern timberline areas have as well as in the conservation of the biodiversity. Social and cultural values are based on the ecological values. Economic value is high when all the aforementioned values are converted, for example by using willingness-to-pay methods, into some economically measurable units.

Managers valued the timberline forests from the viewpoint of reindeer husbandry, tourism and recreation. The value as regards timber production, i.e. forestry, was also mentioned. Forestry was seen as one of the few employment possibilities in the timberline areas. For the managers, the uniqueness of the timberline areas was indicated by the natural state of the forests, meeting of cultural and ecological limits and the importance of these marginal areas to research. The timberline area was seen as an uncommon environment, both ecologically and culturally, as one of the last wilderness areas'. Also, these forest areas were deemed to have a protective role as regards southern areas.

Table 1. Factors that researchers associate with the timberline area.

[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]

Table 2. Factors that managers associate with the timberline area.

[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]

Table 3. The researchers' model of values.

[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]

Table 4. The managers' model of values.

[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]

Model of the future

The model of the future deals with attitudes that people have regarding possible changes in ecological processes in the region or in the use of timberline forests, and what the causes of change and the possibilities to affect this development are. The model also includes information about research needs for the future.

The researchers' model of the future

As regards employment and economic viewpoints, the expectations for growth rested on foreign tourism, i.e. tourists from outside of Nordic region (table 5). Development needs and possibilities were seen especially in sports hunting and wilderness tourism. At the same time, these were also seen as threats to game populations and local communities if not managed carefully. The creation of entrepreneurial networks and development of marketing were seen as being necessary for the development of tourism. The system of agriculture subsidies could be developed in the direction of recreation and tourism. Also, changing the system of subsidies in reindeer husbandry and developing pasture rotation systems should be used to solve the overgrazing problem. The model emphasises that if forestry is to be practised on some scale, local processing of timber should be developed. The future of reindeer herding was seen in a positive light if it is developed together with tourism with an eye on both ecological and economic sustainability.

Table 5. Model of the future - comparison between researchers and managers.

	Researchers	*Managers*
Potential	• Growth potential in tourism	• Growth potential in tourism
Development needs	• Tourism • Hunting and wilderness-related • Service providers networks • Development of marketing • Recreation and landscape management • Subvention system in agriculture • Reindeer husbandry • Pasture rotation systems • Subsidy system • (Forestry) • Local processing of timber	• Tourism • Network development • Nature tourism • Reindeer husbandry - importance for Sami culture
Development views	• Positive: Tourism and reindeer husbandry developed together • Doubtful: Forestry • Climate change could worsen the growth conditions	• Positive: Tourism and reindeer husbandry • Effects of climate change will be mainly positive
Threats	• Hunting and wilderness tourism => game populations and subsistence use for locals • Climate change effects => forestry • Building • Overgrazing • Cooling down of the climate • Changes in values	• Forestry => biodiversity and nature conservation • Air-pollution • Climate change • Price development of timber => economic profitability of forestry => threat to employment
Information	• Criteria for forestry • Effects of landscape ecological planning • Carnivore - prey population dynamics	• Point of view of reindeer husbandry • Relationship between forestry and reindeer husbandry • Effects of different forestry operations • Processing of timber • Local development programmes

The future of large scale forestry was perceived as rather doubtful, first of all because of the effects of predicted climate change on ecosystems and the production capacity of the forests. According to the *researchers' climate change scenario,* there are several unpredictable factors in the future if climatic changes. The climate might get colder or warmer, in which case, the probability for serious biotic damage caused by pest outbreaks is great and this might decrease the growth potential or survival rate of forests. The present threat is that predicted positive effects of climate change on the growth of forests can lead to unsustainable logging. The fear is that the change will be towards more anthropocentric, utilitarian values. Ecological values might suffer if the value of timberline areas for building increases. Overgrazing by reindeer and sheep is a clear ecological threat now. More information is needed on the criteria for practising sustainable forestry, as well as on long term effects of landscape ecological planning. To be able to develop hunting tourism as well as to control grazing animals, carnivore population dynamics should be better understood.

The managers' model of the future

According to the managers, the greatest growth potential was seen in tourism. The outlook for the future of reindeer husbandry was considered rather positive because of its special cultural significance and its importance for local people, especially the Sami people. This option does, however, require development work with the tourism and handcraft industries. Networking needs to be developed in nature tourism and reindeer enterprises. Only a few managers questioned the positive effects of climate change, whereas most of them believed that climate change will affect forest growth positively. The overall production of timber will increase and the timberline will move further north and up the slopes.

Forestry authorities believed in the possibilities of forestry and saw it as a necessary livelihood in the timberline region. Foresters saw it as one of the employment possibilities, threatened by international pressure and low economical profitability.

Nature conservationists and reindeer herders did not share this. model: instead, their model saw forestry in the present situation an unsustainable use of natural resources. Forestry was seen to be a serious threat to biodiversity and therefore to nature conservation. There should be more research conducted from the point of view of reindeer husbandry as well as regarding the relationship between forestry and reindeer husbandry. More research is also needed on timber utilisation and local development programmes.

Conclusions

The clearest difference was in the attitudes adopted towards forestry: that only forestry authorities (managers) believed in the necessity and development potential of forestry within the limits that economic profitability expectations set. The most recent changes in attitudes towards the management and use of natural resources can also be found in this model- the change has been towards so called 'softer or 'greener' values. Also, the *climate change scenarios* were quite different. According to managers' scenario, it is believed that growth conditions will be better following climate change and this will result in expansion of forested areas near the timberline. But according to researchers, this kind of attitude easily leads, or is already leading to unsustainable logging.

It seems that both managers and researchers have the same objectives - economically, ecologically and socially sustainable use of the timberline areas. However, understanding of these concepts appears to vary between groups and this can lead to conflicts. To avoid this, management should be a matter of more equal co-operation between all stakeholders. Also, by practising more open management and planning processes, as well as inter-organisational co-operation, consensus could be reached. Advanced planning programmes taking into account the objectives of all stakeholders or striving to optimise the objectives of all the stakeholders could also clarify the situation between the various interest groups.

Acknowledgements

The research was financed by the Finnish Forest Research Institute and Metsämiesten säätiö Foundation, which also supported participation in the Forestry Beyond the Timberline-workshop held in Akureyri, Iceland 27.- 30.6.2000. Lotta Jaakkola conducted the interviews and the analysis as her MSc. thesis, under the supervision of Mikko Jokinen and Tapani Tasanen.

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WILLIE TOWERS, ALISON HESTER, ANN MALCOLM AND DUNCAN STONE

A Strategic Approach to Native Woodland Expansion in the Scottish Uplands

SAMANTEKT
Veruleg nýskógrækt átti sér stað í Skotlandi á síðari helmingi 20. aldar þar sem einkum innfluttar trjátegundir voru gróðursettar en endurheimt upprunalegra gerða skóga látin eiga sig. Á síðasta áratug varð breyting á og fólk tók að huga meira að endurheimt upprunalegs skóglendis. Skoski náttúruarfurinn (SNH) leggur ríka áherslu á að endurheimt upprunalegra skóga sé nauðsynlegur þáttur í sjálfbærri þróun. Grein þessi fjallar um þróun og notkun á líkani sem aðstoðar við ákvarðanatöku um hvar sé hægt að endurheimta mismunandi gerðir skóglendis. Líkanið byggist á tveimur stórum landfræðilegum gagnagrunnum; jarðvegskorti og yfirborðsgerð (t.d. gróðursamfélögum). Sameining á þessu tvennu gaf gagnagrunn sem lýsir núverandi ástandi. Hver tegund af jarðvegs/gróðurfarsástandi var síðan tengd við tegund skógar sem þar gæti vaxið miðað við þekkingu á þörfum trjátegunda. Þar með verða til kort af mögulegri útbreiðslu mismunandi gerða af upprunalegum skógum. Líkanið hefur verið prófað á nokkrum stöðum þar sem markmiðið er að endurheimta upprunalegt skóglendi og reynst gott hjálpartæki við áætlanagerð. Það gæti einnig nýst við ákvarðanatöku varðandi t.d. verndaráætlanir.

Introduction

Native woodland cover in Scotland has been reduced to less than 5% of its original area as a result of agricultural development, timber harvesting, grazing and climate change. Although there was a considerable planting programme in Scotland in the second half of the 20th Century, much of it was of non-native conifers with timber production as the prime, and in places the sole, woodland objective (Plate 1a). Despite this forest expansion, the proportion of land under trees in Scotland (16%) is about half of the EU average (Scottish Executive, 2000).

During the 1990s, the pattern of planting started to change in response to changing objectives and priorities. Much larger proportions of broadleaved species and Scots pine were planted and this pattern is likely to continue for the foreseeable future. Restoration of the native woodland resource (Plate 1b) is now a conservation priority (Department of the Environment 1994),

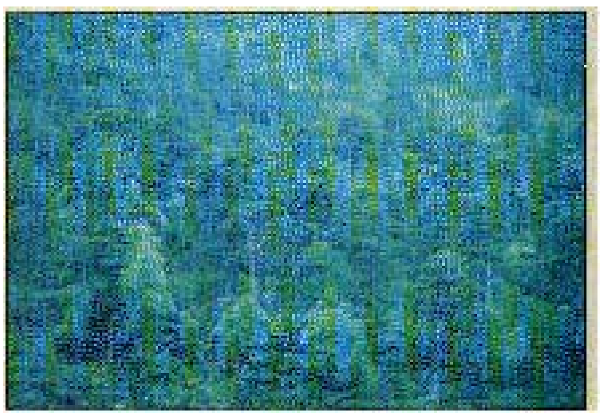

Plate 1a. Typical non-native coniferous woodland.
Plate 1b. Native Pinewood.

and Habitat Action Plans (part of the UK Biodiversity Action Plan) include costed and phased expansion targets for different native woodland types. In addition, there is an increasing awareness that more benefits could be accrued from an expansion in native woodlands if a long-term strategic approach were adopted. This forms the basis of the philosophy of Forest Habitat Networks (FHN). Research undertaken by Scottish Natural Heritage (Peterken *et al* 1995) has demonstrated that the spatial distribution of new woodland can have a major impact on its value for biodiversity and conservation.

Scottish Natural Heritage (SNH) has identified the re-establishment and restoration of native woodland as one of the most important steps towards a sustainable future for the natural heritage. This paper describes the development and application of a modeling tool which is providing SNH, and to a limited extent other groups, with assistance towards achieving this objective.

METHODS

Very little is known about the potential distribution and extent of different woodland types to guide native woodland expansion at regional and local levels. Most surviving native woodlands tend to be highly fragmented and are often radically altered. Comparisons with historical reconstructions from palaeobotanical studies (Bennett, 1996) are likely to be of limited relevance since site conditions have been modified by factors such as climate change and environmental pollution, the removal of the original forest cover, and agricultural cultivation of soils.

A more realistic approach is to predict woodland distribution for current environmental conditions using site suitability models. At MLURI a Native Woodland Model (NWM) is being developed, with support from Scottish Natural Heritage, which links expert knowledge on woodland and scrub habitat requirements with digital biophysical data to predict the occurrence and distribution of a range of woodland communities. The woodland mapped broadly corresponds to 'present-natural', i.e. the native species inherited from primeval conditions, taking into account site and climatic changes to the present day.

Data

Two digital data sources are used in the model: the 1: 250 000 scale National soils map (MISR 1984) and the 1: 25 000 scale Land Cover of Scotland 1988 (LCS88) dataset (MLURI 1993). Both data sets contain a range of information relevant to the prediction of NVC woodland communities.

The 1: 250 000 *scale national soil! map* comprises 580 soil map units, differentiated on geological (soil association), pedological (component soils) and physiographic criteria (landforms). Each soil map unit also has a number of vegetation communities ascribed to it, but this is not a criterion used to distinguish one soil map unit from another. The majority of the 580 soil map units are soil complexes particularly over much of the central, western and northern Highlands, i.e. they contain two or more soil types.

The 125 000 *Land Cover map* provides information on land cover existing in 1988. It is the first ever national census of land cover in Scotland and was captured from the visual interpretation of aerial photographs. The hierarchical classification allows for 126 single land cover features including all the major semi-natural vegetation communities. There are over 1000 mosaic categories used largely to describe the heterogeneous semi-natural vegetation resource. In total, vegetation mosaics rather than single categories cover approximately 30% of Scotland. It provides much more robust and detailed land cover information than the soil map.

The two datasets were overlaid within a Geographic Information System forming a new integrated data set that contains several thousand soil/land cover combinations. These combinations, which are essentially a description of the present site conditions, form the basis of the Native Woodland Model (NWM)'s predictions. Each combination is allocated to an NVC woodland type or to a mosaic of NVC types (see below), based on the relationships between biophysical properties and woodland requirements. It is important to note that the NWM predicts the potential for woodland and scrub types under current soil and vegetation conditions, i.e. with no or minimal intervention.

Modelling

The National Vegetation Classification (NVC) has been used as the basis for most of the woodland categories described, predicted and mapped in this project. Nineteen major UK woodland types and six scrub communities, each with a distinctive mix of trees, shrubs, field and ground flora, are described in the NVC (Rodwell 1991). The range of woodlands within the NVC are associated with different habitats which are described in terms of climatic zone, soil types, terrain and topographic position. These relationships are described in varying degree of complexity and

Table 1. Examples of the NWM decision rules.

Geology and parent Material[1]	Soils[1]	Terrain[1]	Existing Vegetation[2]	Predicted NVC Woodland Class
Glacial till derived from acid rocks	Peaty podzols	Non-rocky hill slopes	*Calluna vulgaris* dominant	Scots pine woodland with heather (WI8)
Colluvium derived from acid rocks	Podzols	Steep valley slopes, often rocky	Acid *Agrostis-festuca* grassland, bracken scrub	WI7/W11 interchangeable category
Moraines derived from acid rocks	Peaty podzols, peat	Moundy moraine	*Calluna vulgaris* and blanket bog	Scots pine with heather (W 18) and scattered woodland on peat mosaic

Note:
[1] from 1250 000 scale soil map
[2] from 1:25 000 scale land cover map

detail by Rodwell (1991) and Rodwell & Paterson (1994). This available guidance was considered to inadequately cover the sub-alpine scrub zone and the wet, often *Molinia-dominated* moorland communities, so further consideration was given to them. Three categories of woodland have been identified and mapped:

I. Where possible, *single* NVC woodland communities.
2. *Mosaics* of woodlands where an area has variable site conditions. Different woodland communities are matched to the different soil types
3. *Interchangeable* categories, where two woodland communities are considered to be equally suited to the site conditions.

The key to the modelling process is the interpretation required to 'translate between the *woodland requirements,* as expressed in the literature and the *site characteristics* as they are represented in the integrated dataset. Table 1 contains examples of the type of decision rule, which links different woodland categories with different sites, used in the model.

APPLICATIONS AND PRACTICAL USES

Scottish Natural Heritage, individually or in partnership with other organisations, are the principal users of the output generated by the Native Woodland Model. Their use of the output is primarily as a strategic planning tool in a number of applications and geographic areas (Figure 1). To date, the uses of the model are as follows:

1. Case studies.

The combined NWM and FHN approach - the model output acting as a template on which the network can develop - has been used in a number of areas. These include:

The Atlantic oakwoods of Western Scotland. These are internationally recognised for their biodiversity benefits and there are strong aspirations and commitments to restore them around Loch Awe in Argyll and to expand them at Loch Sunart in Ardnamurchan. The NWM indicates that sites suited to oak woodland are restricted to the steep narrow lower slopes around both lochs. These contain relatively fertile and freely drained mineral soils. These sites are also valuable for agriculture and coniferous forestry and difficult judgements must be made to achieve the appropriate land use balance. Opportunities for 'restructuring' the coniferous woodland - for example, creating more diversity using native broadleaved species when it reaches the thinning or clear-fell stages - are identified by the model.

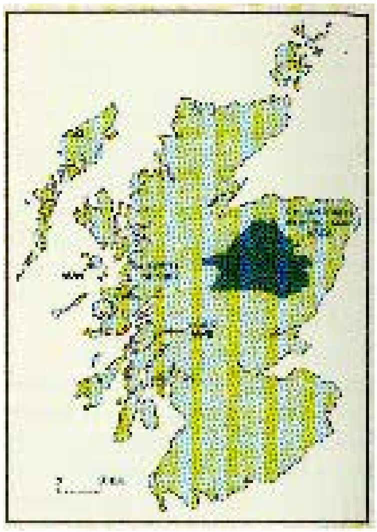

Figure 1. Location of Case Studies.

The Island of Rum. Scottish Natural Heritage wish to restore woodland to the island of Rum to enhance natural biodiversity. This requires woodland on a scale which supports natural processes and within a timescale of approximately 50 years. SNH research indicates that a range of woodland patch sizes (3 -100 ha) and woodland structures (blocks and lightly wooded land) will be required to achieve this. Because of the lack of viable seed sources, planting is the only realistic option. The NWM has been used to provide guidance on the planting scheme both in terms of the species choice and the location and pattern of the different components of the network.

The Cairngorms Partnership Area. The NWM has been used as the basic zoning tool in the recently published Cairngorms Forest and Woodland Framework (Cairngorms Partnership 1999). The Cairngorms contains a large part of the remaining Native Pinewood resource of Scotland, but it also contains a number of other important habitats, notably heather moorland which 'competes' for much of the land suitable for woodland. Based on FHN principles, priority woodland management options and locations have been identified including enhanced management of the existing native woodland resource, priority linkage corridors and new native woodland plantings identified, diversification opportunities on agricultural land and improved management of riparian woodlands. Preferred locations for non-native species were also identified. The Framework is supported by a number of maps which should be used in conjunction with the text.

Figure 2 demonstrates the use of the model output in helping to identify corridors to link existing native woodlands, in this case, of Scots Pine in the Cairngorms, in effect to develop a Forest Habitat Network. By displaying only the woodland categories which are considered to have some potential for pine, priority areas can be identified and resources targeted to them.

For the first time in a strategy/policy document of this type (Cairngorms Partnership 1999), the expansion of montane scrub is a priority objective in specific parts of the Cairngorms. The modelling indicates that in two areas in particular, the existing native pine woodland is close to its natural limit and that natural regeneration, in broad terms, could achieve the 'natural tree line and provide a continuum of habitat from the woodland zone through montane scrub to the

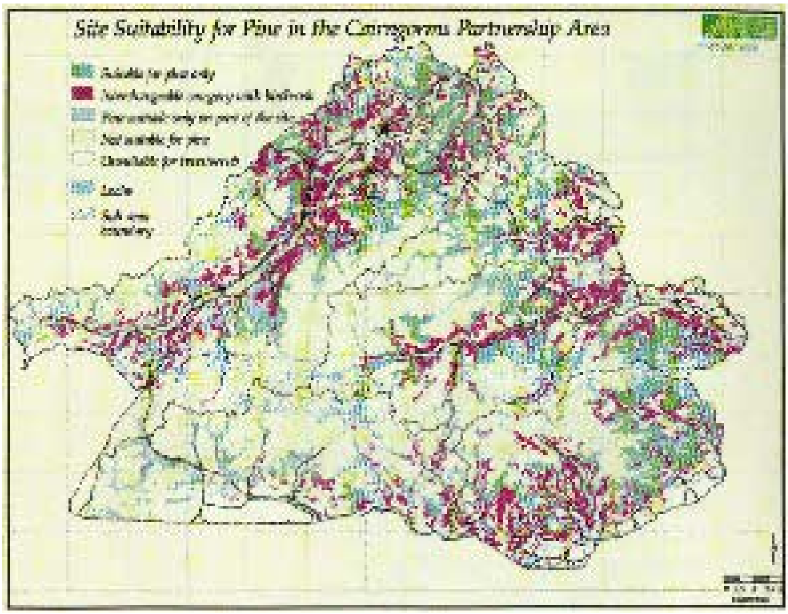

Figure 2. Site Suitability for Pine in the Cairngorms Partnership Area.

unsuitable land on the mountain plateaux. However, a number of actions are required to enable this to happen, notably control of deer numbers and burning. Among the benefits which could accrue from this expansion are increased biodiversity and landscape enhancement.

2. The UK Biodiversity Action Plan (BAP) programme. Scotland does not have a reliable inventory of woodlands that includes species or habitat type. Given the demands of the Habitat Action Plans (HAP) within the BAP for the enhancement, restoration and expansion of a number of woodland types, this is a serious limitation. Dependant on the accuracy of the NWM predictions (by matching the predicted and actual woodland types where both exist), a more comprehensive picture of the current extent of different woodland types can be derived by extrapolation. Some further field validation would be necessary, but this approach should limit the amount of expensive field survey and help target resources. This inventory would act as a statement of the 'Current Status' of woodland within HAPs and allow the various other elements of Habitat Action Plans to be developed from a more robust footing. This approach is more relevant and necessary for some woodland types than others, for example Upland Ashwoods.

3. The Natural Heritage Zone programme

Scotland has been divided into 21 Natural Heritage Zones (Figure 3). These have been derived from SNH's work on Biogeographical Zonation and Landscape Character Assessment. Although the zones are not intended to be precisely determined, they do have distinctive features that distinguishes them from their neighbours. It provides a Framework for SNH to prioritise conservation objectives in sympathy with the existing local character of the land resource.

Figure 3. Natural Heritage Zones in Scotland

Provisional output has been obtained from the model for the twelve Highland NHZs (2, 4-8, 10-15). Radically different potential woodland patterns are being predicted, therefore the native woodland predictions provide some evidence that the original NHZ delineations are relatively robust. This information will assist SNH and others such as the Forestry Commission to prioritise their commitments to native woodland expansion. It will also identify parts of Scotland where native woodland expansion perhaps should not be a priority and where other natural heritage interests will take precedence.

4. Forest Habitat Networks

Scottish Natural Heritage seeks to influence the state-supported programme of afforestation to meet its own objectives. Forest Habitat Networks have been identified as a priority within the Scottish Forestry Strategy (Scottish Executive 2000) and the maps produced by the NWM are seen as key tools to guide the strategic development of Forest Habitat Networks. Furthermore they provide guidance to the Forestry Commission to target resources effectively in fulfilling the UK BAP commitments. In this respect, HAPs and FHNs should not be seen in isolation and SNH are keen that they should be closely co-ordinated.

CONCLUDING REMARKS

The predicted pattern of woodlands appears intrinsically 'correct' to a large range of stakeholders including foresters, ecologists, landowners and planners. Limited validation also suggests that the model predictions are relatively robust *at the broad planning level for which it has been designed.* The model is continually evolving and has been periodically refined and enhanced since its inception. This process will continue as new information and feedback become available. Nevertheless, because of the nature of what they are seeking to represent, there are uncertainties about the quality of the underpinning soils and land cover data, and it is important that the user is fully aware of these.

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NATALIA E. KOROLEVA

Mountain Birch Forests of Murmansk Province, Russia

SAMANTEKT
Í þessari grein er fjallað um veðurfar, landslag, jarðgrunn, jarðveg og gróður í birkiskógum í Múrmanskhéraði, öðru nafni Kolaskaga. Ilmbjarkarskógar þekja 20% af Kolaskaga, þ.m.t. stóran hluta láglendis bæði norðan- og sunnanmegin, og mynda vel afmarkað belti milli barrskógarins og túndrunnar í fjalllendi á miðjum skaganum. Birkiskógarnir flokkast í tvær megingerðir: 1) þar sem lyngtegundir eru ríkjandi í botngróðri ásamt fléttum og mosum, sem er oft á fremur þurru og rýru landi og 2) þar sem jurtir eru ríkjandi í botngróðri, oftast á rakari og frjósamari svæðum. Fjórir undirflokkar eru af ‚lyng'skógum, tveir af ‚jurta'skógum og einn lendir þar á milli. ‚Lyng'skógarnir eru oft gisnir og trén smávaxin, margstofna og kræklótt en á frjósamara landi verður skógurinn þéttari og trén stærri og beinvaxnari. Fjallað er um áhrif mengunar, sinuelda, hreindýrabeitar og traðks á skógana.

Introduction

Birch forests occupy about 20% of the Murmansk Province covering a large area of the plains and low mountain areas and forming a well-defined narrow band between coniferous (pine and spruce) forests and tundra in high mountains. A narrow zone of birch forest fringes the eastern and south-eastern maritime part of the Kola Peninsula, mainly on the coastal slopes, and bordering with seashore heathlands, and coniferous forests and peat bogs - from the inland countryside.

The aims of this study are:
- to survey mountain birch forest ecosystems in the Murmansk area, being the most north-eastern area of Fennoscandia,
- to present results of classification of plant communities, and
- to assess the human impact.

Geology, geomorphology and soils.

The area of study covers most of province's mountains and north shore of the White Sea. As far as geomorphology is concerned, the study area is subdivided into two remarkably different sections - the west and the east. The western part is sharply rugged, with mountains attaining 800 - 1200 m, the most prominent being the Sal'nye Tundry, Chuna-tundra, Monche-tundra, Khibinskie and Lovozerskie mountains. Because of recent glaciation, the mountains have flat surfaces and steep slopes, with well-developed glacial morainic deposits. The eastern part has a landscape consisting of a range of low uplands (the collective name is Keyvy) situated in the central part of peninsula, which decline gradually towards the Southeast.

The parent rocks in the birch forest area are of various structures and composition (Geologicheskoe..., 1958). Sub-maritime birch forests are located on maritime sediments. Mountain birch forests grow on multiform bedrocks (granite, gneiss, granulites, and shist) which has been subject to basic and ultrabasic random intrusion. As a result of glaciation, quaternary morainic deposits almost entirely cover the bedrock, and soils derived from these are characterised by sandy texture with a lot of stone and gravel in the soil profile.

Podzolic soils prevail in all the birch forests of Murmansk Province, but owing to rich parent bedrocks in the Khibiny and Lovozersky mountains and particular climatic conditions (more rainfall and snow cover, and a longer growing season) the podzol layer formation is reduced. This soil, called Al-Fe humic podzol, has a relatively high humus content in its mineral layers, amounting to as much as 5,8% in the illuvial horizon, whereas the podzol horizon contains 4.1 % (Ushakova, 1997).

Climate.
In general, the climate of the central part of the province is more continental than the climate of the eastern and coastal parts (Anon. 1965, 1968). The western part has a higher precipitation, than the central and coastal area of the White Sea. The average annual temperature is below 0^0 C in the whole area, but inland and at the White Sea it is clearly colder than in the western region. The western and coastal parts of the region show evidence of maritime climate by their reduced summer rainfall (less than 35 % of the annual distribution for June, July, and August).

Data collection.
Field work was carried out in 1990-1999 in the Khibiny, Keyvy, Chuna-Tundra, Monohe-tundra and Salnye Tundry Mts. and along the shore of the White Sea. A total of 82 sample plots (10 x 10m) were made in birch stands considered uniform in floristic composition and structure. Percentage cover of each taxon was estimated using the following variant of the Braun-Blanquet scale: << 1% cover, < 1%, 1-5%, 6-25%, 26-50%, 51-75%, and 76-100%.

Altitude, aspect and slope were estimated with the help of a map and compass. Height and diameter of trees were measured and the density of canopy and cover of understory species were estimated. The botanical nomenclature follows Lid and Lid (1994) for vascular plants, Ignatov and Afonina (1992) and Konstantinova et al. (1992) for mosses and Santesson (1993) for lichens.

In addition, birch forest vegetation samples taken by Avrorin et al (1935), Nekrasova (1938) and Neshatayev & Neshatayeva (1993) were included. These samples were comparable to Braun-Blanquet releves.

Data analyses
The numerical technique TWINSPAN, which gives both a grouping of species and classification of sample plots (Hill, 1979), was used to analyse the more than 110 releves (stands). Three levels of division were taken into account in order to produce the final community units. The TWINSPAN sequence of species was rearranged in order to characterize the groups of communities obtained in terms of their floristic composition and to reveal clearly at a glance the similarity and dissimilarity of samples.

Results
The two large groups delineated by the first TWINSPAN division correspond to heath and meadow birch forests (Fig. 1). Within these, the following birch forest community types were defined.

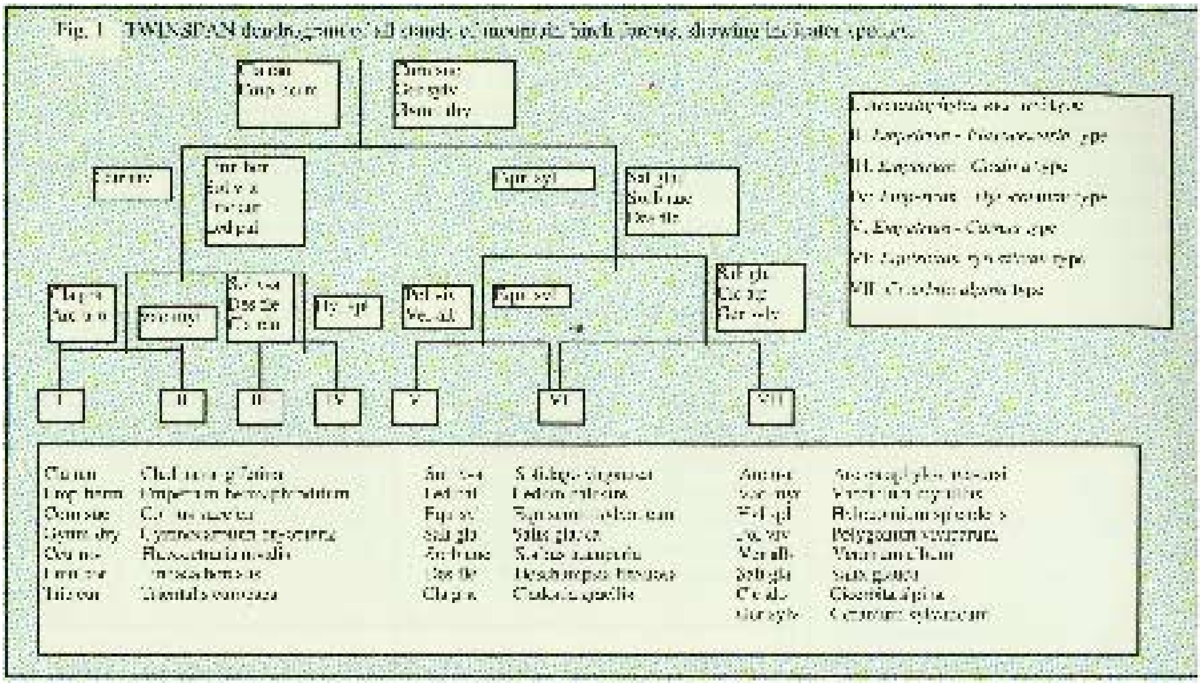
I. The *Arctostaphylos uva-ursi* type of heath birch forest is widely distributed at low elevations, mainly on southerly plains. The tree layer is open, with policormic birches growing far apart, and the field-layer consists mainly of *Arctostaphylos uva-ursi* and *Empetrum hermaphroditum.* Lichens of the genera *Cladina* and *Cladonia* form the ground layer.

II. The *Empetrum - Flavocetraria* type comprises the driest and the most infertile birch stands. They are common in the mountains of the eastern part of the province. The birches here grow in bush islands, standing far apart. Dwarf shrubs and chionophobous lichens of the genera *Cladina, Cladonia* and *Flavocetraria* form scattered cover.

III and IV. The third group of birch forests is where mosses make up an essential part of the ground-layer. Here birches are often in the form of individual trees, the stands occupying more sheltered positions. There is a dense ground layer with a large proportion of mosses and liverworts, some vascular plants and the constant presence of mesophilous foliose lichens. This group is divided into sub-units, which differ in accordance with the abundance of lichen and moss in the ground layer: the *Empetrum - Cladina* and *Empetrum - Hylocomium* types.

V. The *Empetrum - Cornus* type contains the transitional characteristics of the heath to meadow birch forest. These stands occupy rather steep warm slopes with good water supplies served by numerous brooks. Polycormic oblique birches form a dense tree layer and the field layer consists mainly of herbs, although dwarf shrubs are a significant component too. The ground layer is weakly developed (almost absent). Owing to their particular position and ecological conditions these stands provide shelter to some interesting rare Red Book species such as *Epipactis atrorubens, Veronica fruticans* and *Castillea lapponica.*

VI and VII. The two last types represent meadow birch forests, which are mainly situated close to springs and rivers as well as in mountains in the submaritime zone, where meadow forests are most prevalent. The birches here are tall, straight or oblique. Mountain ash and alder are common in the tree-layer. Luxuriant tall herbs, grasses and ferns form



the field layer and the ground layer is poorly developed. The *Equisetum sylvaticum* type comprises fresh meadow birch forests situated in ravines, on moist slopes in mountains, and on seashore terrains. The *Cicerbita alpina* type comprises more humid birch forests, situated mainly in mountains, near brooks and springs.

Whereas birch forests of Fennoscandia form oroarctic (mountain), arctic and maritime timberlines (Hamet-Ahti, 1963, Ahti et al., 1968), in Murmansk Province most birch forests form only the oroarctic timberline. They are common on extensive plains in central and western parts of the province at altitudes of 150- 350 m a.s.l., where lichenous, mossy, heath forests prevail. Fresh heath and meadow birch forests are common in high mountains of the province, and are associated with springs and brooks. Meadow and heath submaritime birch forests are practically absent from the Barents Sea coast and occur only on the White Sea coast as a rather narrow zone, where they are found at elevations from 20 to 50 m a.s.l.

Human impact.

In Murmansk Province, birch forests cover a large area that varies considerably with regard to local population density and level of industrial development, that determines the character and pressure of anthropogenic impact. The most populated and most industrial sectors are in the central part, situated along the Petersburg-Murmansk road, and in the north-western part. The eastern part of Murmansk Province is almost uninhabited, with the main pasture area of reindeer husbandry located there.

Industrial pollution. Industrial development in Murmansk Province started in the 1930's, and nowadays numerous plants and ore mines cause essential damage to biota. Fertilizers, etc. are produced from apatite ores in the Khibiny mountains. Copper-nickel smelters produce copper, nickel and cobalt and waste gases containing sulphur dioxide and dust are considered to be the major damaging factors causing deforestation around Monchegorsk, Nikel and Zapoljarnyi. Wastes from the aluminium plant in Kandalaksha and ore-developing factories in Kovdor and Olenegorsk are lower, but contribute much to tree-line ecosystem degradation in neighboring mountains.

Fires and Felling usually accompany the industrial impact overall in causing forest degradation. Although the felling is of minor occurrence in the timberline area, ground tires almost entirely (and sometimes repeatedly) cover areas adjoining industrial centers. They can have a dramatic effect, when the ground layer and litter burn, bare soil slips downhill to reveal the moraine horizon. This leads to complete ecosystem degradation, and fires are even reported to be a leading factor affecting forest degradation in the industrial zone (Selikhovkin, 1993).

Reindeer husbandry provides a traditional form of subsistence for the Saami people. The wild reindeer population amounts to around 16 thousand whereas tame reindeer number around 70 thousand. Although these populations cover various areas, tame reindeer are tended under more or less the same natural conditions as wild reindeer (as far as the Saami people are concerned). Their migration is dictated by the availability of fresh pastures. During the summer, the reindeer disperse over a wide range of forest territory, because at this time they favour the leaves and twigs of the mountain birch as well as the various grasses and herbs. Cladina-lichens are only eaten when wet. Damage to vegetation caused by reindeer trampling seems to be minimal. The winter pastures are situated mainly on the plains and have a predominance of Cladina vegetation. Tame reindeer are concentrated near the villages during winter and, as a result, winter pastures around the villages become overgrazed. This has resulted in the establishment of grasses such as *Nardus stricta, Deschampsia cespitosa* and D. *flexuosa*.

Recreation and tourism. The surroundings of industrial centers and more distant sites are similarly popular destinations for some number of people - either for relaxation, or exploring activity. Skiing, camping and hiking have locally detrimental effects, but vegetation usually recovers after the pressure decreases. The most successful invaders of such sites are graminoids, apocarpic mosses, and fruticose and foliose lichens. Succession after such small-scale disturbance often results in some increase in species diversity compared with adjoining sample plots. The damage caused by off road vehicular traffic, local drilling and local tires, especially caused by spilling of fuel, are potentially serious causes of degradation of landscapes.

Conclusion

Although many studies have investigated birch forests as part of the vegetation cover of in Murmansk Province, numerous unsolved problems relating to birch forest ecosystems still exist. On the one hand, *Betula pubescens* is reported as a species to be highly resistant to aerial pollution, whereas on the other hand, birch timberline eco systems are referred to as the most sensitive in relation to damage caused by pollution. To make a comprehensive study of the birch forests' ability to resist and regenerate after disturbance caused by pollution, we need:

1) to use the available information on their structure and composition relative to the habitat;

2) to examine all possible birch forest eco system parameters, such as the coenopopulation structure and properties, the litter and composition and processes, the microbiota and so on;

3) to organize the investigations along gradients of the main ecological factors.

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VALENTINA YU. NESHATAYEVA

Classification of the stone- birch *(Betula ermanii* Cham.) forests of Southern Kamchatka

SAMANTEKT
Í þessari grein er fjallað um flokkun skógargróðurs í friðlöndum á Suður-Kamtsjatka þar sem steinbjörk *(Betula ermanii* Cham.) er ríkjandi. Að baki liggja vettvangsrannsóknir, sem hafa náð yfir langan tíma. Steinbjarkargróðurinn var skilgreindur með aðferðum gróðurfélagsfræðinnar í gróðursveitir, nánar tiltekið sem fjórar undirsveitir *(Betuletum ermanii filipendulosum camtchaticae,* B. *e. varioherbosum, B.e. alnosum camtschaticae* og B. *e. sorbosum sambucifoliae).* Þessar einingar voru settar undir þrjá gróðurflokka *(Betuletea ermanii alteriherbosa,* B. *e. varioherbosa* og B. *e. fruticosa)* og eina gróðursyrpu (formation) *Betuletea ermanii).* Vakin er athygli á að steinbjarkarskógurinn sem kannaður var á Kamtsjatka er á suðurmörkum útbreiðslu sinnar. Hann er einkum að finna í árdölum, lægðum og á sjávarkömbum. Samanburður var gerður á þeim gróðureiningum, sem hér eru skilgreindar og steinbjarkarsamfélögum á öðrum svæðum Kamtsjatkaskagans.

The plant cover of Southern Kamchatka has not been well enough studied. Only some itinerary investigations have been carried out at the beginning of this century (Hulten 1927 and 1974, Pavlov 1936, Pavlov and Chizhikov 1937). The brief characteristic of stone-birch forests at the territory of the South Kamchatka State Reserve has been given by E. Hulten (1974) and the author (Neshatayeva 1988). The present paper is devoted to the study of the phytocoenotical diversity of Kamchatka stone-birch forests at the southern boundary of their areal.

Materials and methods

Field work was carried out in 1985-1986 and 1990-1991 at the territory of Southern Kamchatka nature reserve, Elizovo environs (Moroznaya Mt.) and at the Paratunka river basin. 120 releves were made in stone-birch stands that were uniform in floristic composition and structure over an area larger than the predefined minimal area, i.e. at least 100 m^2. Transects crossing the typical landscapes were layed from the shore of the Sea of Okhotsk to the volcanic plateau. The transects were divided into pickets every 100 m. The size of sample plots layed along the transects was 20 x 20 m. Percentage cover of each taxon and layer was estimated. Altitude, exposition and inclination were estimated with the help of a map, barometer and compass. All the plant community releves are stored at the Laboratory of plant community ecology (Komarov Botanical Institute). For the tree layer the diameter and density of crowns, the average and maximal height of trees, average and maximal diameter of stems were measured. The table method of releve analysis being elaborated at the Department of Geobotany of Saint-Petersburg University (Neshatayev 1987) has been used. The plant community classification based on the principles of the Russian ecologo-phytocoenological school has been elaborated. The nomenclature of syntaxa was used in accordance with the "All-union Code of phytocoenological nomenclature" (1989).

Results

As the result, the classification of stone-birch forests has been elaborated. Four associations, three association groups and one formation were distinguished. The brief characteristics of the syntaxa are given below.

Formation *Betuleta ermanii -* Stone-birch forests.

Association group I. *Betuleta ermanii althiherbosa*

The plant communities are characterized by the high (1,5 m) tall-herb layer with the coverage 80-85%. The species of broad-leaved tall-herbs are abundant *(Filipendula camtschatica, Senecio cannabifolius)*.

Association I. *Betuletum ermanii filipendulosum camtschaticae*

Diagnostic features: dominants - *Filipendula camtschatica, Senecio cannabifolius, Calamagrostis langsdorffii;* constant species: *Cirsium kamtschaticum, Trientalis europaea, Maianthemum dilatatum, Allium ochotense, Angelica genuflexa.* The total coverage of the herb-laver - 80-85%, the moss layer is extremely rare (less, than 1%). Solitary mosses are found: *Brachythecium reflexum, Dicranum scoparium, Drepanocladus uncinatus.* The plant communities occur usually on the alluvial soils at the valleys of rivers and rivulets, at the well-moistened sites. The association was described at the South-West Kamchatka (Pavlov 1936, Pavlov and Chizhikov 1937), at the Central Valley (Lipshits and Liverovsky 1937) and at the Kronotsky State Reserve (Eastern Kamchatka) at the altitude up to 300 m above the sea level (Balmasova 1994).

Association group II. *Betuleta ermanii varioherbosa*

The plant communities belonging to the group are characterized by the thick herb-grass layer (coverage 70-80%) with the predominance of the meadow mesophytic herbs, by the high floristical diversity (35-40 species per sample plot) and by the compound vertical structure. The group was firstly described at the south-west of Kamchatka under the name of *Betuleta herbosa* (Pavlov 1936).

Association 2. *Betuletum ermanii varioherbosum*

Diagnostic features: at the first sublayer of the herb-grass layer (the average height - 90 cm) the following species are abundant and constant: *Calamagrostis langsdorffii, Artemisia opulenta, Aruncus dioicus, Geranium erianthum, Aconitum maximum, Thalictrum minus.* At the second sublayer (20 %) *Maianthemum dilatatum* predominates, *Trientalis europaea, Moehringia lateriflora, Trillium camschatcense, Galium kamtschaticum, Lilium debile, Fritillaria camschathensis*, *Viola selkirkii, Pedicularis resupinata* are constant. Moss layer is abscent. The total coverage of the herb-grass layer is 70- 80%. The communities of this association occur at moderhumus stratified volcanic ash sandy soils. Communities with the similar floristical composition have been described at the south of Bolsheretsky district (Pavlov 1936, Pavlov and Chizhikov 1937)

Table 1. Geobotanic description of the Stone-birch forests.

[illegible]

and at the Kronotsky State Reserve (Balmasova 1994).

Association group III. *Betuleta ermanii fruticosa*

The group is characterized by the well-developed shrub layer with tall (the height - 1,5-2 m) subalpine shrubs and elfin-woods (the coverage - up to 80%) and by the poor floristical composition of communities.

Association 3. *Betuletum ermanii alnosum kamtschaticae*

Diagnostic features in the shrub layer (coverage up to 80%) *Alnus kamtschatica* (coverage 50-60%) predominates, *Sorbus sambucifolia* (20- 25%), *Spiraea beauverdiana* (5%) are common. In the herb-grass layer (coverage 40-60%) the following species are constant and abundant: *Calamagrostis langsdorffii, Maianthemum dilatatum, Trientalis europaea*, *Solidago kurilensis, Viola selkirkii.* Moss layer is absent. The communities occur at moderhumus stratified volcanic ash soils with the volcanoclastic subsoil, they are common at the mountain slopes and terraces in the transitional zone from stone-birch forests to alder thickets. This association was firstly described at the Eastern Kamchatka at the altitude 500-700 m above the sea level at the upper boundary of stone-birch forests (Balmasova 1994).

Association 4. *Betuletum ermanii sorbosum sambucifoliae*

Diagnostic features: in the shrub layer (coverage 50-70%) *Sorbus sambucifolia* (coverage 30%) predominates, *Pinus pumila* (up to 20%) is abundant. Alder shrubs are absent. Solitary shrubs of *Lonicera kamtschatica* and *Spiraea beauverdiana* are found. At the herb-grass layer (coverage 70%) *Gymnocarpium dryopteris* predominates, the following species are abundant and constant: *Calamagrostis langsdorffii, Cirsium kamtschaticum, Chamerion angustifolium.* Moss layer is absent. The communities of this association occur at the basin of Ozernaya River, at the Kurile Lake hollow, at the slopes of Dikiy Greben range. The similar plant communities were described at the Eastern Kamchatka at the altitude up to 200 m a.s.l. at the river valleys (Balmasova 1994), but the eastern variant of this association differs by the significant share of ferns (coverage 5-10%): *Phegopteris connectilis, Dryopteris austriaca, Athyrium filix-femina*.

Discussion

The phytocoenotical diversity of stone-birch forests of Southern Kamchatka is considerably decreased being compared with that of Eastern Kamchatka districts where 18 associations and 6 association groups have been estimated (Balmasova 1994). At the investigated area we did not find fern-rich, grass-rich (with *Calamagrostis langsdorffii)* and dwarf-shrub-rich association groups that have been described at the territory of the Kronotsky state Reserve. At the regions of Southern Kamchatka stone-birch forests occur mainly on the alluvial soils at river valleys. At the territory of the South Kamchatka Reserve stone-birch forests are common at the basin of Ozernaya River and the environs of Kurile Lake. At the Pacific shore of Southern Kamchatka stone-birch forests can be found as well on the maritime terraces at the altitude 5-10 m above the sea level. At the Sea of Okhotsk shore stone-birch forests are absent. This is connected, probably, with the cooling influence of cold and wet aerial masses of Sea of Okhotsk, with a high amount of precipitation and frequent fogs. The altidudional limits of stonebirch forests at the Southern Kamtchatka are from 5-10 m a.s.l. (at the river mouths of Iljinskaya, Gavriushkina, Try Sestry rivers) up to 350-400 m a.s.l. (the Kurile Lake environs). The single birchtrees can be found in the mountains up to 430-450 m a.s.l. The southern boundary of the stonebirch occurrence lies along the right bank of Try Sestry river.

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Viðskiptavinir athugið !
Starfsemi Viðarmiðlunar
hefur verið flutt að Mógilsá

ARILD O. GAUTESTAD AND FRANS E. WIELGOLASKI

Dynamic modeling of the mountain birch forest ecosystem:

challenges related to space, time and scale

SAMANTEKT
Evrópuverkefnið „Samspil manna og birkiskógavistkerfis“ (HIBECO) beinist að samspili manna og umhverfis á svæðum þar sem birki *(Betula pubescens* ssp. *czerepanovii)* myndar skógarvistkerfi. Tölvulíkan verður notað til að fá heildstæða mynd af möguleikum til landnýtingar og til að gera áætlanir um sjálfbæra nýtingu þessa vistkerfis. Þessu hagnýta líkani er ætlað að tengja rannsóknir á mismunandi sviðum plöntulífeðlisfræði, beitarvistfræði og félagshagfræði. Það er nokkuð erfitt að hanna flókið líkan af víxlverkun ólíkra þátta, t.d. vaxtar skógarins, beitar á trjánum og nýtingar manna á vistkerfinu. Til að raunhæft hagnýtt líkan fáist verður að taka tillit til flókins samspils þátta á ólíkum stærðarkvarða og í mismunandi loftslagi. Í þessari grein er tekist á við vandamál í hönnun líkansins.

The EU-funded project "Human Interactions with the Mountain Birch Forest Ecosystern" (HIBECO) is focusing on the human dimensions and natural conditions of the Nordic mountain birch *Betula pubescens* ssp. *czerepanovii* forest ecosystems. Twenty scientists from Finland, Sweden, Norway, Iceland, Greenland, UK, Germany and Canada participate in the project. The biology of these ecosystems has been studied in less detail over the last twenty years through the Nordic Subalpine-Subarctic Ecology group (NSSE). Results from these studies are presented in a UNESCO Man and the Biosphere series volume (Wielgolaski 2000). Based on these results and results from the HIBECO project, as well as results from other sources, a computer-based model is to be developed as part of an integrative work connected to formulation of management scenarios and development plans that will ensure future sustainability of this ecosystem. These aims are to be achieved in an interdisciplinary manner, combining birch productivity, herbivory and socio-economics.

From a modeling perspective the cross-disciplinary integration of interactions between birch forest growth, herbivory and anthropogenic exploitation and other interactions represents a great scientific challenge. For example, sealing complexities over space as well as time under different climatic scenarios will be considered in order to produce a model that can contribute to the development of guidelines for future sustainable management. In this paper some of these challenges related to fine- and coarse scale interactions in space and time are illustrated by examples from birch-insect interactions as a part of the preparative phase of the model development.

Various subspecies and varieties of mountain birch form vast, continuous forests in subarctic and subalpine parts of Fennoscandia, Iceland, Greenland, Scotland and in northwestern Russia, particularly on the Kola Peninsula (Väre 2000). These forests are in some regions mostly unmanaged by man, while the trees in other parts have been strongly influenced by human activities. Mountain birch is utilized for firewood and sometimes building materials like wallboards, and especially young birch shoots are important as forage for domestic ungulates like reindeer and sheep (e.g., Helle 2000, Aradottir and Arnalds 2000). Over the last centuries patches and larger areas of birch forests within some regions have been transformed into summer farming areas. Even if some of these areas have been abandoned as farming and mowing areas again (Bryn and Daugstad 2000) and have gradually been reclaimed by birch (or reforested with spruce!), the mountain birch forests are still strongly influenced by traditional forms of utilization in parts of their distributional range. New influences like tourism, cabin “villages", forestry, and an increasingly finely woven web of roads have also emerged. In addition to these direct interactions between man and birch forests, expected future climatic shifts towards generally milder winters, regionally increased level of summer precipitation and a higher frequency of extreme weather events also represent a potential influence on birch forests even at the ecosystem level and at a continental scale (cf. Skre 2000). Thus, on this background of stronger and potentially more severe influence on mountain birch forests from man, it is of great importance to develop scenarios for future sustainability of various management regimes.

The model will take into account main factors influencing forest productivity, and various direct and indirect human interactions with the birch forest. These interactions include anthropogenic direct and indirect factors like domestic reindeer and sheep herbivory and trampling, forestry, tourism and other vegetative influences. Interactions between ungulate and insect herbivory, and periodically strong impacts from outbreak species like the autumnal moth *Epirrita autumnata* (e.g., Tenow *et al.* 2000, Neuvonen *et al. 2000)* will also be included in the model. The model will also be applied to simulate scenarios for a changing climatic regime due to global warming, including its direct and indirect effects on birch forest productivity, distribution and abundance, and pattern of herbivory.

Model perspectives

Models in general contribute to the objectivity of a theory. The mountain birch forest model assessment against data provided by the 20 project participants and the literature provides a test of the model's effectiveness. Three levels of assessment can be made for complete models (Ford 2000): fitting, predicting, and revealing different results. These three topics will be described below using scaling problems and complex population dynamics as an illustrative example.

Fitting is not a strong assessment criterion for a specific ecosystem theory. Yet it can be difficult to achieve and when it is achieved there has to be a thorough understanding of how that was done. Fitting is more like an alternative mathematical and computational description of a given verbally formulated model describing a system with its suggested intrinsic functional relationships.

Even if fitting is considered being a weak assessment criterion, it will be an important aspect of the HIBECO mountain birch ecosystem model. The model will not be a *realistic* model in the sense that fitting is meant to reproduce a specific mountain birch forest system in a *specific* area to as great detail as possible. Rather, it will be a model that is able to simulate what will be considered the most important elements shaping the forest system today and in the future in a "representative" virtual landscape and its socio-economic and cultural context. Thus, fitting in this case refer to being able to simulate the system's key processes in *general terms,* where a delicate balance between realistic model details and generalizing power of functional principles for this ecosystem is maintained.

When formulating the model one is forced to be explicit about which components (forcing and state variables) to include in the model and which to exclude. Further, one is forced to be explicit about formulation of the systems functional relationships (flowcharting). Parameters' and state variables' spatial and temporal variability in statistical terms must be documented from real data or "educated guesses", and compared with model simulation outputs in the validation phase.

Prediction is more valuable than fitting and is widely used in both statistical modeling and system simulation as validation. The HIBECO birch forest model will be of the latter kind (spatiotemporal computer simulation). Hopefully, it will contribute to shed light on hypotheses related to complex relationships in this ecosystem, including scale-related problems.

For example, when validated and verified against historic time series and environmental conditions for local insect outbreaks, can one be reasonably confident that it will be able to predict the next outbreak in a specific area, given the necessary parameter adjustments and other necessary background data? The autumnal moth outbreaks happen with a periodicity of 9-10 years at regional to local scale in parts of Fennoscandia (Neuvonen *et al.* 1999, 2000 and references therein), while the outbreak intervals are more complex at the even finer scale of birch forest stands (e.g. Tenow and Bylund 1989, Tenow *et al.* 2000) and at very coarse scales (Neuvonen *et al.* 1999). Various ways of formulating the local birch/moth/parasitoid/climate interactions in the model may contribute to verify, falsify or modify hypotheses related to proposed synchronization factor(s) and reasons for outbreaks under various local ecological conditions and scales of observation. If validated against proper real historic data, it will represent an additional contribution to already performed modeling efforts for this system (e.g., Virtanen *et al.* 1998) if the HIBECO model predicts with confidence not only the actual outbreak - based on a given a set of conditions (model input) - but also its expected severity and dispersion on a local and regional scale.

The present modeling program will unfortunately not have resources to actually make such a detailed forecast for a given locality, due to the substantial magnitude of data that would be necessary for this kind of forecast. However, the key point is that the model- whether it regards insect outbreaks or other important aspects of the mountain birch forest system - can be expected to create forecasts with a reasonable confidence level for such a complex system *even for specific localities* - given the necessary and *a priori* specified quality and quantity of model input.

Revealing results of a different kind is the strongest kind of model assessment. In this case the model predicts something not expected and when searched for through more research, is found to occur. Even if the available resources for modeling work always are limited, revealing new and unexpected results that can be validated against real data is will always be a modeler's dream and ultimate goal. This level of model assessment will be illustrated in more detail below.

Exploring sealing complexity

Sealing complexity is one of the potential arenas where the HIBECO model may bring in new hypotheses and reveal new results, in addition to offering a tool for simulation and validation against data for relationships that are formulated *a priori*.

For example, consider the hypothetical local population dynamics of a virtual animal species, which shows exponential growth until it overshoots the environment's carrying capacity, and then goes extinct. This example is by no way realistic enough to simulate actual insect outbreaks in the mountain birch forest ecosystem, but it will be used below to illustrate the kind of process complexity that may appear in any spatially extended system

In a non-spatial, "mean field", modeling context the kind of outbreak scenario described above is not viable without the inclusion of some kind of an immigration term (forcing function). Without "rescue" from immigration, a model population which goes extinct from intrinsic "boom and bust" dynamics will obviously not be able to reappear and increase again after extinction.

Modeled in a spatial arena with a regional extent, however, population dynamics that are unstable locally may still show a viable regional population at coarser scales within a given spatial arena for the model. As illustrated in Fig. 1, this may happen even without including any simulated "rescue effect" (Brown and Kodric-Brown 1977) from the

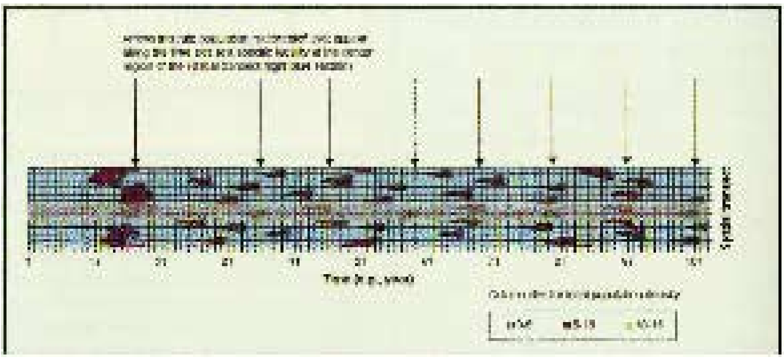

Fig. 1. Local population density fluctuations are simulated in a spatial grid system consisting of 12 local grid cells. Each vertical column in the grid consists of 12 cells which represent a transect of 12 local "patches" in the virtual landscape at a given point in time. The successive columns from left to right in the Figure shows the transect at successive points in time, for example years, in a series of 101 time intervals. The color codes for each grid cell represent local population densities, ranging from low and medium (blue) to high (brown) and extremely high (yellow) (the latter is only represented with one "peak" at time 14 from the left and located at cell 11 from the bottom). Thus, a single vertical column of 12 cells shows local population density variations over this spatial transect at the chosen point in time, while a specific horizontal row consisting of 101 cells shows how the local density in this cell varies over time over 101 time intervals. The density could be for example number of individuals per spatial unit on average in a sample taken within a grid cell at a given point in time. A specific center-region of the transect is marked with pale colors. For this specific center-region of between two and three grid cells, temporal outbreaks are marked along the time axis with the vertical arrows along the top of the grid. A close inspection of this center-region shows that sometimes the outbreak appear at one end of this center-region, and sometimes at the other end, or somewhere in the middle. The complex spatio-temporal fluctuations in abundance - which appears by reading the grid columns from left to right in the Figure - are due to the specific set of model rules in this simulation: A percentage of the individuals in a "booming" patch is defined to migrate to neighboring patches during the following "bust" event of local extinction. In this manner, this migration process may either re-populate a previously extinct local population, or the new immigrants simply add more density to the local population at that time.

"outside", i.e. with zero rate of immigration to the model arena as a whole. The reason for long-term survival can be found in the complex spatio-temporal fluctuations that prevail at finer scales due to local dispersal. At any point in time there is always some local population or another increasing in number, and thus being ready to contribute to revitalize neighboring localities through dispersal during a future local "bust". Contrary to the mean field scenario where the model population responds dynamically as a single unit, the spatially structured population in Fig. 1 gives migration as an *intrin*sic process of the system rather than an extrinsic forcing function. Thus, the immigration rate to the total population in Fig. 1 is set to zero (only local inter-patch dispersal takes place) and the total population still survives in the long run in spite of frequent local extinctions at fine scales.

From an empirical point of view, this kind of effect on spatio-temporal fluctuations on population viability may be called "common knowledge" (e.g., Andrewartha and Birch 1954). However, the point is that from a theoretical perspective, the inclusion of space in the model opens for a huge step forward in terms of realism. There has been a long tradition in theoretical ecological modeling where this kind of realism has been more or less ignored, but present-day modeling has become much more sophisticated (McGlade 1999).

The "toy" model simulation insight from formulating the spatial dimension(s) explicitly instead of "averaging out" local processes may initiate a cascade of new investigations involving real data as well as model refine-

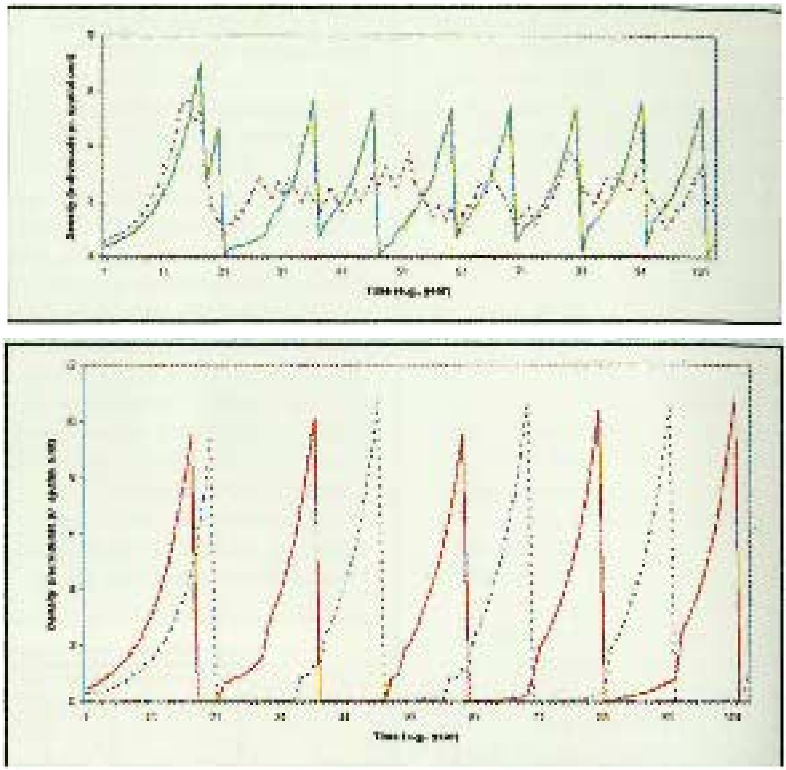

Fig. 2 (a). The mean local abundance from the pale-colored center-region in Fig. 1 is presented as a traditional time series diagram with density at the ordinate and time at the abcissa (continuous line). The time units could for example be years. The density could be for example number of individuals per spatial unit on average in a sample taken within a grid cell at a given point in time. For comparison, a coarse-scale view of the mean density for the 12-cell transect as a whole is also shown (stippled line). The coarse scale series is aperiodic, while the finer-scale center-region series shows an apparent 10-step periodicity for most of the time series
(b). The separate time series for two neighboring center-region grid cell densities show an approximately 20-year outbreak cycle, with one of the patches lagging approx. 10 time steps behind the other patch's peak in abundance. In comparison to Fig. 2 (a), we see that periodicity is strongly dependent on observational scale in this example, spanning from period 20 at fine scale (1 grid cell), period 10 at somewhat coarser scale (2-3 grid cells), and aperiodicity at "regional" scale (12 grid cells).

ments. Analysis of the “toy" model example in Fig. 1, and similar models from the literature, predicts that neighborhood dispersal leads to a pattern of outbreaks that tend to be dampened due to spatial fluctuation asynchrony at coarser scales than the correlation length given by the typical scale of dispersal distance. New data used to test this hypothesis may then lead to a more coherent theory with a better predictive power than the starting point of a too simplistic non-spatial model.

Another interesting observation from a specific model output in Fig. 2 is that one particular "time series" apparently produces a ~20 temporal unit interval periodicity at the grid cell scale, ~ 10 unit periodicity at spatial scale 2 (two neighbor grid cells), and aperiodicity at coarser scales. The new questions that can be raised from this result are then (for example), what makes

Table 1. Examples of some of the important processes to be included in the HIBECO mountain birch forest ecosystem model. Suggestive links to their respective characteristic scales (response times and spatial correlation lengths) are also given. The spatial and temporal aspects of a given factor may be correlated (not shown). Preliminary definitions of scale. Fine spatial scale, approx. 500-2000 m^2; Coarse spatial scale, approx. 100-200 km^2 and beyond; fine temporal scale approx. 1 day; coarse temporal scale: approx. one season or longer.

Birch growth

Space:

Fine scale processes: Local exposition, altitude, soil quality, local climate conditions

Coarse scale processes: Global warming effects, provenance differences and regional adaptation (e.g., frost tolerance of buds)

Time:

Fine scale processes: Episodic influence from frost and herbivory

Coarse scale processes: Dieback due to repeated defoliation from insect attack over consecutive years (threshold effect); herbivory inhibitory response (delayed density dependence) on expense of maximum growth rate, successional stage effects.

Herbivory

Space:

Fine scale processes: Sheep as a fine-scale forager (stand edges vs. interior parts: Soffia Arnthorsdottir, *personal comm.)*

Coarse scale processes: Sheep as a coarse-scale forager due to site fidelity (home range). For example, problem with re-growth on clear-cuttings if domestic animals turn the clear-cutting into intensively utilized grazing patches (facilitating grass on expense of herbs and new birch tree stems sprouting from tree stumps); long-distance dispersal of moths (correlation length functions for ballooning and female movements must be clarified for the model)

Time:

Fine-scale processes: Local insect outbreaks limited to old-age smaller stands and single trees

Coarse-scale processes: Development of ungulate site fidelity to (and cultural transmission over generations) a local network of preferred grazing patches.

Direct anthropogenic and socioeconomic influence

Space:

Fine-scale processes: From mixed-age stands to more even-aged stand structure due to small clear-cuttings (loggings firewood and forestry),

Coarse scale processes: Distance to roads and villages (firewood and forestry: probability of a tree being logged at old age, and probability of birch forest patch or stand mosaic); macroeconomic conditions for forestry: management plans with influence from official regulations and land use arrangements.

Time:

Fine scale processes: Episodic trampling effects on young birch shoots and seedlings at fine spatial scales

Coarse scale processes: Shifting regulation policies for a region.

"scale 2" special in this case? May the answer be revealed by exploring the relationship between spatio-temporal abundance pattern generated by the model under variable parameter settings for intrinsic growth rate, dispersal length and dispersal rate? These aspects among others need to be explored during the HIBECO modeling work, as an important validation of the birch-insect interactions.

Table 1 gives some additional examples of scale-related challenges for the model development. Scaling complexities emerge as a result of making the model sufficiently realistic (in accordance with definition above) by making it spatially explicit.

Conclusion

Spatially explicit models in general may often give unexpected results in comparison with their spatially implicit counterparts, and their greater level of realism make them a better starting point for validation against real systems like the mountain birch forest ecosystem.

On the other hand a spatially explicit model puts huge demand on data, which also (at least for some parts) need to have specific spatially explicit details (e.g., insect outbreak series with spatial details, not just a local time series with a mean abundance variable).

It is important to remember the old proverb for any modeler: "garbage in - garbage out". Thus, a model's level of refinement and complexity must always be calibrated and balanced in accordance with the quality and quantity of the available data. This is a prerequisite for model validation and production of scenario simulations with sufficient level of confidence. The actual HIBECO model development will be performed with this balance in mind

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ULRIKA DAHLBERG AND COOMAREN P VENCATASAWMY

Biomass of mountain vegetation in optical satellite data

SAMANTEKT
Lífmassi gegnir mikilvægu hlutverki í svæðisbundinni og hnattrænni kolefnishringrás. Þörf er á að meta lífmassa gróðurs í fjalllendi Skandinavíu. Þess vegna beindist þessi forkönnun að undirbúningi hugsanlegrar notkunar gervihnattargagna til að meta lífmassa fjallagróðurs. Stuðst var við eina IRS LISS III gervihnattarmynd frá 1. september 1998 og gögn af athugunarstað á fjallasvæði fyrir norðan Svíþjóð (68°20' N, 18°50' E). Aðhvarfsfall var metið með IRS LISS III gögnum og gögnum af jörð úr reitum innan athugunarsvæðisins. Landslag og lág sólarhæð í fjöllum á háum breiddargráðum geta orsakað mun á birtu í halla sem snýr í mismunandi áttir, og voru þessir þættir útskýrðir í aðhvarfsgreiningunni. Fjögur bönd og landslagsbreyturnar sin(halli), sin(átt), samverkun milli þeirra (sin(halli) x sin(átt)), og hæð voru prófuð sem skýribreytur með lífmassa sem svarbreytu. Einungis bönd 3 og 4 voru marktæk, það kom á óvart að landslagsbreytur bættu ekki aðhvarfsgreininguna. Þetta er sennilega vegna þess að ekki fengust nægilega margar hallagerðir fyrir athugunarsvæðið til að marktækar niðurstöður fengjust. Jafnframt getur landslag haft bein áhrif á magn lífmassa, sem væri nægilega stór til að gera samverkunina ómarktæka.

Vegetation biomass plays an important role in regional and global carbon cycles. For example, climate change affects the vegetation cover of the earth, which influences the amount of CO_2 stored in plants and soil. These effects are especially large in sensitive areas such as the circumpolar ecosystem. There is therefore a need for improved estimates of biomass of forests at a global scale in such areas (Brown et al. 1999). However, there are not many studies that estimate biomass of the mountain ecosystems in Scandinavia. Due to access difficulties and high variability of the ecosystem in those areas, field data measurements are not practical. A viable alternative for such estimations is the use of optical satellite remote sensing data. Several studies have already proposed using digital satellite data for the assessment of forest parameters such as biomass (Hagner 1990, Anderson et al. 1993, Tiwari 1994, Fazakas et al. 1999, Reese and Nilsson 1999, Steininger 2000). Remote sensing is suggested as the best method to estimate forest parameters at a global or regional level (Koch 1996).

Although there exist many approaches to estimate biomass from satellite images these methods need to be evaluated for mountainous vegetation, especially because of the slopes and elevation characteristics of the Scandinavian Mountains and the relatively low sun angles in the area. Regression models are the most commonly used method for this purpose, and the individual wavelength bands from satellite images, or vegetation indices derived from a combination of wavelength bands, are usually used as explanatory variables (Anderson et al. 1993, Hagner 1990, Salvador and Pons 1998, Steininger 2000). The results, however, have differed. Steininger (2000) found a significant linear relationship between mid-infrared reflectance, derived from band 5 of Landsat TM-data, and biomass in Brazilian stands. However, Salvador and Ponds (1998) found poor fits of simple or multiple regression models of forest variables with the individual bands of Landsat TM and the normalised difference vegetation index (NDVI) as explanatory variables. Anderson et al. (1993) did not find a good relationship between biomass from sample points and a number of vegetation indices such as difference (DVI) , ratio (RVI) or normalised difference (NDVI), derived from

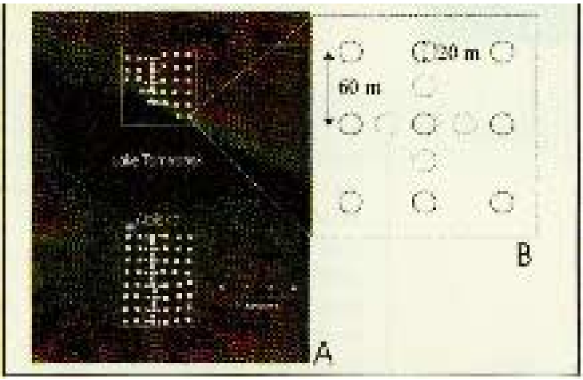

Fig.1. A: The study area on Southern and Northern sides of the Lake Torneträsk. The test site consisted of plots grouped into clusters (white squares) with 500 m or 1 km between each other. **B:** Most clusters consisted of 9 circular plots (solid lines), but a few had four extra plots inside the cluster (dotted line) and two plots 500 m to the east and west from the central plot (not visible).

Fig. 2. The forest on the south side of Lake Torneträsk.

three Landsat TM scenes. On the other hand they found significant relationships when the satellite data were stratified into vegetation index classes and related to an average biomass from ground data.

In many large area studies Landsat TM data are commonly used. However, nowadays there exists a range of optical satellite data, which can potentially be very useful. For example, Tiwari (1994) used all bands from IRS LISS (Indian Remote Sensing Program, Linear Imaging Self-Scanning Sensor) data to classify different crown cover classes. Allometric functions were estimated between crown cover and biomass using a log-linear model with R2 values around 0.97. The accuracy obtained with this method is dependent on the crown cover classification and the allometric model between crown cover and biomass.

One of the problems of using remote sensing in mountainous and high latitude areas is that the topography and low sun angle will cause differences in illumination of slopes in different directions. The effects of topography on classification and in extracting estimates from satellite images are well documented and several topographic correction models have been suggested (Teillet et al 1982, Parlow, 1996 Gu and Gillespie 1998, Gu et al. 1999). In most cases the cosine of the incidence angle (cos(i)) is used as a correction factor to reduce the effect of different illumination of slopes in different directions (aspects). Another more empirical approach is to include the product of the sine of slope with the sine of aspect (sin(slope) x sin(aspect)) as an interaction term in the regression function. This would correct for the extra variation due to the relationship between topography and satellite data.

Other problems are that for periods there are no good satellite images from any optical satellite available. This relates to the short vegetation period in the Scandinavian Mountains, which is typically only about two months, which often are cloudy.

The aim of this study was to establish the possibility to use satellite data for estimating biomass of mountain vegetation, in an area in Northern Sweden. For this attempt, regression functions were estimated using IRS LISS III data and ground data from a test site. The topographic variables sin(slope), sin(aspect), the interaction term (sin(slope) x sin(aspect)), and the elevation were also tested in the regression. The IRS data were chosen because it was a cloud free scene that covered the whole test site during the short vegetation period.

Materials and Methods

Study area

The study area was located in a mountainous area in northern Sweden (Latitude 68°20/ N, Longitude 18°50/ E) on the Southern and Northern sides of Lake Torneträsk (Figure 1A) The hills at the southern are pre-dominantly slope to the north, whereas the steeper hills at the northern area slope to the south and west. The vegetation on both sides of the lake was predominantly heath and open mountain birch forest *(Betula pubescens* ssp. *czerepanovii)* (Figure 2), but on the Northern side the mountain birch forest was richer and consisted of tall herb meadows with a few relatively large birch trees (Figure 3). The tree line was

Fig. 3. The forest on the north side of Lake Torneträsk.

Fig. 4. Estimated wood biomass when the function was applied to the satellite image.

about 650 m above sea level, and the mountain birch forest had several times, since the 1950's suffered from insect outbreaks that had killed many trees (Bylund 1995).

Ground data

The test site (Figure 1A) was established during the summer of 1997, and consisted of 869 permanently marked circular sample plots with a radius of 10 m, grouped into clusters of 9 or 15 in a regular grid with 30 to 500 m between plots (Figure 1B). Distance between clusters was 500 m to 1 km. All plots were located using GPS. On each plot all trees were measured for diameter above breast height (DBH), coverage of shrubs estimated in part of 10 per shrub species, and soil type registered. Slope, aspect and elevation were extracted for each plot, from a digital elevation model (DEM). Biomass of trees and shrubs were calculated for all plots using allometric equations based on the variables that were registered for each plot. These equations had previously been estimated by regression analysis of field-measured biomass of mountain birch trees and shrubs taken from the same study area (Dahlberg et al 2001). Since we were only looking at mountain birch forest in this preliminary study, all plots without trees were excluded.

Satellite data

The satellite data was one cloud free IRS LISS III scene from 1 September 1998 (Table 1).

Table 1. Characteristics of IRS LISS-III

Band	Wavelength (µm)
1 Green	0.52-0.59
2 Red	0.62-0.68
3 Near IR	0.77-0.86
4 Mid IR	1.55-1.70

Although the image was geometrically corrected using a 500 m resolution DEM by the Swedish remote sensing company Observation, Mapping and Monitoring (OM&M), we found residual distortions in the image, which produced uncertainties in the location of the plots. This is a typical problem with satellite images in mountainous areas (Itten and Meyer 1993) that should be taken into account when analysing the results. To reduce the distortions as far as possible within our test site, the scene was further geometrically corrected with ground control points from aerial orthophotos and resampled using the cubic convolution method (weighted average of 16 surrounding pixels to approximate the value of one pixel) (Lillesand and Kiefer 2000). The pixel values for each field plot were extracted using cubic convolution method.

Regression

Multiplicative linear models were estimated for leaf - and wood biomass, where the pixel values from all bands (Table 1) of the image, as well as sin(slope), sin(aspect), their interaction term and elevation were tested as explanatory variables. This model can be represented as:

$$y = e^{a} \cdot x_1^{b_1} \cdot x_2^{b_2} \cdot \ldots \cdot \varepsilon$$

This was transformed using a logarithm:

$$\ln(y) = a + \sum_{i=1}^{n} b_i \ln(x_i) + \ln(\varepsilon)$$

where:

ln(y) becomes the response variable,

a and b_i are parameters to be estimated,

x_i are the explanatory variables.

and ln(ε) is normally independently distributed error term with a zero mean and an unknown constant variance (ln(ε) -NID(0, σ^2)). It is assumed that the explanatory variables are not subject to random variation.

Results

Only bands 3 and 4 of the LISS III image were found to be significant as explanatory variables for biomass (Table 2). We did not find the variables sin(slope), sin(aspect), the interaction term or elevation significant.

When the resulting functions were applied to the IRS LISS III image, we got biomass values on the lake, and quite high biomass values on snow beds as the regression function simply extrapolates the function to all the pixel values. Figure 4 shows the result when the function for wood biomass is applied to band 3 and 4 of the IRS LISS III image, after snow and water have been masked out. The tree line appears clearly on the image, which also shows higher biomass at south facing slopes. This is consistent with the observations made in those areas. The estimated mean value of wood biomass within the whole area of the test site was 9100 kg/ha, and the mean leaf biomass was 800 kg/ha.

Discussion

The standard statistical tests (ANOVA and adjusted R2) indicate that there could be a relationship between biomass and IRS LISS data in the study area. The adjusted R2 is rather low (0.30 and 0.21) which could be a result of many variations related to geometric and radiometric distortions in the image and also because of noise. The only explanatory variables that were significant for predicting biomass were bands 3 and 4 of the IRS LISS III data. These bands were expected to predict biomass since vegetation highly reflects the energy in the near infrared (band 3) and mid infrared (band 4) bands while energy in the visible region (bands 1 and 2) are much less reflected (Lillesand and Kiefer 2000). In mountainous areas there are often differences in solar irradiance on adjacent slopes up to 900 W/m^2 (Parlow 1996). This means that the same vegetation at different slope angles can have significantly different reflectance. The interaction term should have been significant but they were not. There are two possible explanations for this. The range of slopes available for the test area for trees was not sufficiently large to produce a significant result. Furthermore, topography can also have a direct influence on the amount of biomass, which could be large enough to make the interaction term not significant. These will be investigated further in the future.

The biomass map produced when the regression functions were applied to the IRS LISS III image is very similar to the truth. The biomass on the north side of the lake is high as the forest there is rich and trees are much larger. There are also more undergrowth and shrub (Figure 3), which made the total biomass higher. Furthermore, the mean values of wood and leaf biomass (9100 kg/ha, 800 kg/ha) for the test site are comparable with the mean value that was calculated from the 869 test plots (8000 kg/ha, 700 kg/ha) (Dahlberg et al, in prep), that are representative for the area.

This study has demonstrated the information content of IRS LISS III data for estimating biomass at landscape level. Although most of the known distortions of the images were not fully corrected, a good fit for regression models was obtained.

Table 2. Estimated parameters for regression functions for wood (BIOMWood) and leaf biomass (BIOMLeaf).

Response	R^2	MSE	Constant	lnIRS3	lnIRS4
ln(BIOMWood)	0.300	0.522	11.192	3.3857	-3.7947
ln(BIOMLeaf)	0.214	0.636	2.760	2.7849	-1.7587

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ODDVAR SKRE

Temperature adaptations in growth and carbon balance in relation to nutrient level in seedlings of Betula pubescens from different populations in Scandinavia

SAMANTEKT
Sagt er frá tilraun þar sem mældir voru vaxtarþættir, köfnunarefnis- og kolvetnainnihald í mismunandi plöntuhlutum og öndun í mismunandi plöntuhlutum á birkiplöntum af þremur mismunandi kvæmum ræktaðar við mismunandi áburðargjöf og í mismunandi hæð yfir sjávarmáli. Í ljós kom að plöntur sem ræktaðar voru við lágt hitastig (meiri hæð) og lágt N drógu einkum úr vexti sprota og laufblaða. Engu að síður var N-innihald í laufblöðum þessara plantna tiltölulega hátt, sérstaklega hjá norðlægasta kvæminu. Við þessar aðstæður eykst sérstök tegund öndunar í laufblöðum sem ekki tengist vexti en við hana sparast N.
Í rótum er hins vegar venjuleg öndun og þær vaxa. Norðlæg kvæmi virðast vera sérstaklega aðlöguð þessum kringumstæðum enda er mikill vöxtur ofanjarðar ekki heppilegur þegar skortur er á næringu.

Abstract
Seedlings of three different populations of white birch (Betula pubescens) were grown in fertilized peat at two different nutrient levels equivalent to 1 and 10 g N m^{-2} yr^{-1} at 50 m and 450 m elevation in southern Norway.

The experiment showed a strong accumulation of carbohydrates in roots of high altitude plants relative to low altitude replicates. In these field-grown plants normal and alternative (cyanide-resistant) respiration was measured on stem and root segments and on excised leaf discs from three Betula pubescens populations. The total respiration rates decreased with temperature in leaf discs and stem segments, while there was an increase in roots. At low nutrient level there seemed to be a depression of respiration rates in shoots at high temperature, and most of it was cyanide-resistant, i.e. not related to growth.

The ecological significance of these findings is that at low temperatures increased respiration rates in leaf and stem tissue may lead to reduced growth. At high temperatures, however, increased respiration in roots may indicate increased root growth rates that may increase nitrogen absorption rates and lead to increased photosynthetic capacity, compensating partly for carbohydrate exhaustion. The increased alternative respiration at low nutrient level may be a mechanism to prevent growth at unfavorable growth conditions.

Introduction

In areas with a summer and a winter season, plants have evolved different methods to survive the unfavourable season, and the selection pressure is determined by abiotic factors rather than by competition (Kallio 1984). Nitrogen availability is the most important limiting factor for plant growth at high latitudes (Ågren 1985). On cold soils decomposition of organic matter is slow and the concentration of inorganic nitrogen and phosphorus is low. Uptake rates of nitrogen and phosphorus have been shown to be strongly temperature-dependent as a result of active uptake in roots (Chapin 1980, Karlsson & Nordell 1987). The energy required for this active uptake is usually supplied through dark respiration or growth respiration, which is therefore an important limiting factor for growth at low temperatures. The existence of an alternative respiration as an overflow mechanism which is not linked with ATP-production (Beevers 1970) is further evidence for this relationship. At the same time, a possible role of this mechanism as a way of preventing undesired growth (Lambers 1980) raises question as to the relationship between growth and plant survival in cold environments.

As a case study to examine climatic adaptations and acclimation potential (Billings 1974), mountain birch ecotypes could give valuable information about growth/respiration relationships. As an old immigrant, Betula pubescens is assumed to have evolved close adaptations to the climate at its provenance. In addition to respiration, measurements of growth and photosynthesis in birch are necessary to obtain information about climatic adaptations and the acclimation potential in birch ecotypes.

Because arctic ecotypes of plants seem to be more adapted to a low-growth strategy for survival than southern and lowland ecotypes (Chapin 1979, Skre 1991a) one would expect a lower proportion of ATP-linked growth respiration in northern ecotypes than in their southern relatives. To investigate possible differences in response to nitrogen application between birch ecotypes and to what extent slow-growing birch seedlings have evolved alternative respiration as a growth-regulating mechanism, a series of experiments was initiated, where normal and cyanide-resistant dark respiration was measured in various birch tissue types at different temperature and nutrient levels. Measurements of growth parameters and chemical analysis of plant tissue were performed on parallel subsamples, to investigate the source-sink relationships in plants of different origin.

Material and methods

Seeds from three Betula pubescens populations were sown in moistened and fertilized peat in May 1987. The seed populations were:

- BA = Löten southeastern Norway ($60^0$51'N) 200 m altitude
- BS = Fana southwestern Norway ($60^0$16'N) 50 m altitude
- BJ = Kevo, northern Finland ($69^0$44'N) 200 m altitude

When the plants had developed four leaves, they were transferred to 0.6 l plastic pots filled with a mixture of peat and pearlite in the ratio 2:1. The plants were allowed to recover for 2 days at low temperature and then distributed at two field sites at different altitudes.

- Fana ($60^0$16'N) 50 m altitude
- Kvamskogen ($60^0$24'N) 450 m altitude

Each pot received 100 ml of nutrient solution per week during the remainder of the season with the following composition

- +N Complete nutrient solution equivalent to about 10 g N $m^{-2}yr^{-1}$
- -N Complete nutrient solution but without nitrogen
- -P Complete nutrient solution but without phosphorus

Due to peat decomposition, some nitrogen and phosphorus were available even in the pots where no such nutrients were added. Soil samples were therefore taken from different treatments and sites at the end of season for control.

Temperatures were recorded at nearby meteorological stations, mean monthly, daily mean and extreme temperatures are given in Table 1.

Table 1. Monthly means and extreme temperatures (°C) at Fana and Kvamskogen 1987.

	Mean temp.	Monthly maximum	Monthly minimum
Fana			
July	14.6	25.8	5.2
August	13.8	21.5	5.4
September	10.0	18.5	1.4
October	9.4	18.[illegible]	2.5
Kvamskogen			
July	12.5	24.2	[illegible]
August	10.9	18.7	1.5
September	7.[illegible]	[illegible]	1.5
October	6.8	15.1	1.5

On September 14^{th}, while the leaves were still green, five plants per population and treatment were harvested and separated into leaf, stem and root tissue. This was repeated on October 28^{th} after leaf abscission. Dried plant tissue was then analysed for total nitrogen and total non-structural carbohydrate content. Total nitrogen was measured by the Kjeldahl method after digestion in sulphuric acid and for total non-structural carbohydrates the anthrone method was used (Dreywood 1946). Duplicate samples were homogenised and digested in 10 ml 20% $HClO_4$ for 10 min at 20 °C (Hansen & Møller 1975) after which the anthrone reagent was added. After subsequent heating the absorbancy at 490 nm was recorded against digested starch, measured as glucose equivalents. Cellulose is not digested by perchloric acid and therefore not included in the test (Clegg 1956). This was confirmed in the present experiment (Skre unpubl.) The C/N ratio is therefore defined as the ratio between the total non-structural carbohydrate content and the total nitrogen content, as measured by the Kjeldahl method.

Measurements of alternative and normal dark respiration

The experiment was repeated the

Table 2. Variance ratios (F) and significance levels for chemical components in different tissue types of birch seedlings, grown at varying temperatures and nutrient levels, harvested before and after leaf fall 1987. The following symbols are used:
NST and NRT = nitrogen content (mg/plant) in stem and root tissue, CST and CRT = non-structural carbohydrates (mg/plant) in stem and root tissue, and S, Rand T = C/N ratios in stem, root and total plant tissue respectively. Significance levels are: *P<0.05, **P<0.01. DF = degrees of freedom. R2 = square multiple correlation coefficient, SS = sum of squares. The nitrogen and carbohydrate content has been subjected to logarithmic transformation. Interactions that are not significant in any variable, are not included in the table.

Source	DF	N_ST	N_RT	C_ST	C_RT	S	R	T
Population	2	10.6*	9.0*	85.9*	73.6*	140.8*	126.5*	251.0*
Temperature	1	9.9+	8.5+	10.5+	15.2*	12.4*	18.2*	30.9*
Nutrient level	I	20.9*	19.2*	14.2*	11.7+	6.8^0	13.8*	24.4*
Time	1	2.3	2.1	1.8	0.3	34.2*	6.5+	21.2*
Pop x temp	2	3.0	0.8	15.7*	3.2	14.5*	9.8*	17.3*
Pop x nut	2	0.7	0.5	1.6	1.2	3.5^0	5.1+	10.0*
Temp x nut	I	10.5*	0.6	11.8*	3.0	0.1	0.0	0.3
Nut x time	1	0.5	0.0	1.5	0.9	1.2	10.0+	12.0+
Temp x nut x time	I	1.8	6.2^0	0.0	2.4	5.4°	9.6+	13.0*
Pop x nut x time	2	0.6	2.6	0.7	0.4	3.1	15.0*	17.4*
Temp x pop x nut x time	2	0.5	0.3	0.4	0.2	1.4	10.6*	12.0*
error ss	23	3.0	4.5	3.3	4.3	299	839	315
total ss	47	14.1	1904	41.0	42.5	5556	16100	10792
R^2		0.79	1.77	0.92	0.90	0.95	0.95	0.97

next spring (1988) for extended respiration studies. Because of lack of germination the western coastal BS seed source was replaced by the subalpine BH seed source.

The dark respiration was measured by the Warburg manometric technique on growing leaf, stem and root tissue by the method described by Skre (1992a). The cyanide-resistant (alternative) respiration was measured by means of a modification of the method of Bahr & Boriner (1973) and Lambers et al. (1983).

During the sample period the plants reached the stage of 12 visible leaves, and measurements of cyanide-resistant respiration were performed on leaf discs from leaf number 7 and 8 from the stem base. These leaves were assumed to be in a stage of maintenance with stable respiration rates. Similar measurements were carried out on 4 mm stem and root segments, grown at different elevations (temperature) with or without added nitrogen. All measurements were carried out at 20°C in darkness. Each sample contained six leaf discs and 10- 12 stem or root segments, and four parallel replicates were run per treatment.

Statistical treatment of data

All variables were tested by GLM variance analysis (Goodnight 1976). The analysis included growth measurements and results from chemical analysis.

Results and discussion

Effects of fertilization on growth

There was a strong temperature effect on the growth of plants in the field experiment (Fig. 1) with 2-3 times higher plant biomass at harvesting in plants from the low elevation site than in plants from the high elevation site (see also Skre 1992b). In addition to the direct temperature effect on shoot growth, there was also an indirect effect because of raised soil temperature and more rapid uptake rates of nutrients (cf. Karlsson & Nordell 1987). The destructive samplings (Fig. 1) confirmed the results of Karlsson & Nordell (1987) and showed that the effect of added nutrients was strongly temperature-dependent. At the lowland site, growth was roughly doubled by adding nitrogen and phosphorus to seedlings of the lowland population (BA) as compared with plants without these two elements, with most of the growth increase taking place in the shoot. As a result the shoot/root ratios were higher in fertilized than in unfertilized plants of this population. The biomass increased in all three populations after nitrogen addition, relative to non-fertilized plants. At the high elevation site, the effect of added nutrients was much weaker and hardly significant, but the unfertilized plants produced fewer and smaller leaves (Skre 1992b).

There was a strong accumulation of nitrogen in leaves of fertilized plants at the high temperatures (=low elevation) and a correspondingly strong accumulation of carbohydrates in roots of unfertilized plants at lower temperatures (Fig. 2). The experiment confirmed earlier results and showed that the leaves are the main sink for nitrogen and the roots and stems are the main sink for carbon. Leaf proteins account for 60-70% of the nitrogen in Betula papyrifera, while 8-11 % is found in nucleic acids (Chapin & Kedrowski 1983). When grown at low temperatures and deprived of nutrients, mountain birch tended to keep a high nitrogen concentration in its tissue by reducing its growth. This is similar to Thornley's (1972) and Chapins (1979) conclusions about arctic plants. Only in the two southern populations was there a reduction in nitrogen content a result of low nutrient strength. At the low elevation site, a substantial part of the nitrogen in roots of fertilized plants from the southern coastal population (BS) was translocated

Table 3. Variance ratios (F) and significance levels for cyanide-resistant dark respiration rates in different tissue types of birch seedlings from three populations, grown at varying temperatures and nutrient levels. Significance levels are: *P<0.05, **p<0.01. DF = degrees of freedom. The SHAM interactions are not included. R2 = square multiple correlation coefficient, SS = sums of squares.

Source	DF	Leaf discs	DF	Stem segments	DF	Root segments
Population	2	7.0+	2	0.3	2	10.9*
Temperature	1	43.8*	1	4.3^{0}	1	114.7*
Nutrient level	1	17.2*	1	5.0^{0}	1	2.0
Pop x temp	2	1.0	2	0.6	2	17.4*
Pop x nut	2	6.4+	2	4.0^{0}	2	5.7+
Temp x nut	1	1.6	1	8.7+	1	5.8^{0}
Pop x temp x nut	1	2.0	1	0.3	1	0.5
SHAM	3	6.3*	3	2.6	3	7.2*
error ss	68	3.11	51	0.81	70	1.54
total ss	82	8.34	65	1.38	84	6.27
R^2		0.63		0.42		0.75

to the stems prior to leaf abscission, while at the high-altitude site and in non-fertilized plants most of the nitrogen seemed to be re-translocated back to the roots (fig 3). The northern ecotype (BJ) kept a much higher (2.7- 3.8% vs. 0.9-2.6%) nitrogen content in its stem and root tissue than the corresponding plans from southern ecotypes (Skre 1993), indicating higher metabolic activity as an adaptation to low temperatures and a short growing season (cf. Billings 1974).

The C/N ratio in roots of the coastal BS population increased in fertilized plants prior to leaf abscission at the lowland site while there was a reduction at the high elevation site (Fig. 3). Carbon accumulation was strongest in fertilized plants. This indicates that at the low-altitude site, some photosynthesis was taking place in leaves after the first sampling in September, while in unfertilized plants and at high elevations there was less photosynthesis after this date. The results are in accordance with Ericsson (1979), who found that increased growth caused by nitrogen or phosphorus addition, or high temperature, reduced starch reserves in *Pinus sylvestris* followed by a new increase in carbon reserves and C/N ratios after growth termination.

Non-structural carbohydrates comprise up to 30% of the root biomass in arctic plants (Chapin 1979). In the present experiment, as much as 50% of the root biomass was found to be non-structural carbohydrates, indicating that the birch roots have a high capacity for storage, and that mountain birch is able to keep a high root growth rate, even at very low nutrient levels where the aboveground growth is restricted. Root growth therefore seems to have the priority over shoot growth at nutrient limitation, particularly in northern ecotypes.

Dark respiration rates

There was a strong increase in total and cyanide-sensitive respiration (e.g. growth respiration) in leaves grown at high temperatures, as a result of nutrient addition (Fig. 4). The result is in accordance with Waring et al. (1986), who found that addition of nutrients (N, P, K) resulted in a relatively stronger increase in respiration rates than in photosynthesis.

In nitrogen-deficient plants the proportion of cyanide-sensitive respiration relative to total was higher in roots than in leaves (Fig. 4).There was almost no cyanide-sensitive respiration in leaf tissue grown at high temperatures, while there was still some in roots and stems. Thus, at high temperatures and low nitrogen level, growth is directed towards non-green tissue, especially roots. This is a useful adaptation because it would tend to increase the uptake capacity for nitrogen and help in restoring the balance between production and consumption. When the C/N ratio is decreased by adding nitrogen, growth (and growth respiration) is again shifted towards leaf and stem tissue. The significant temperature x nutrient interactions in the cyanide-sensitive respiration rates of leaf and root tissue (Table 3) and the corresponding positive effect of nutrient level on high temperature treated roots support this conclusion (Fig. 4).

Generally, respiration rates were increased in leaf and stem tissue by low-temperature treatment, while they were decreased in roots. The increase was partly of the cyanide-sensitive type, indicating shoot growth at the expense of root growth. Most of the low-temperature induced increase in respiration rates, however, was of the cyanide-resistant type (e.g. alternative respiration). Lambers (1982) similarly found that when Plantago was transplanted into nutrient-deficient solution, the alternative respiration in leaves increased, to avoid the production of nutrient-deficient tissue that would make the plants more susceptible to water stress.

There was a significant effect of temperature and population on alternative respiration rates in leaf and root tissue and also a significant population x temperature interaction in roots, i.e. there was no temperature effect on the northern (BJ) population (table 4).

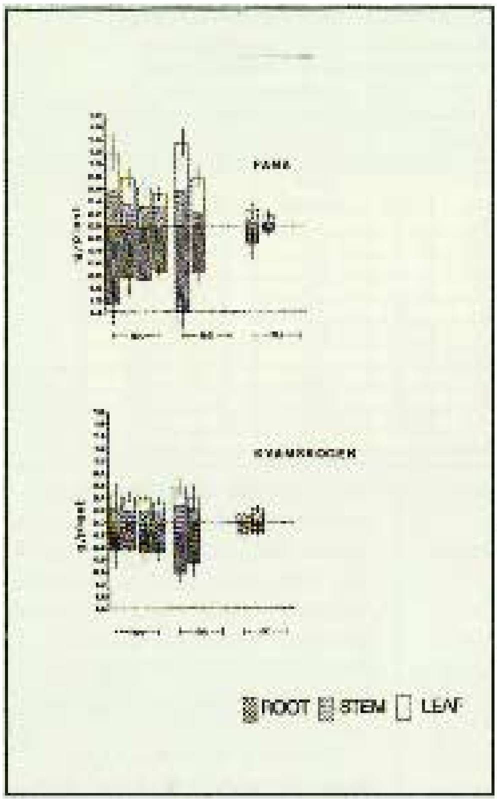

Figure 1
Biomass per plant (g DW) of leaf, stem and root tissue at harvesting (14.9.1987) in fertilized birch seedlings, grown for two months in peat at two different altitudes in western Norway, Fana (50 m) and Kvamskogen (450 m). Mean values with 2 s.e. indicated on total shoot and root biomass. Treatments are (from left to right): +N, -N,-P, -NP (the two last treatments shown only for the BA population only).

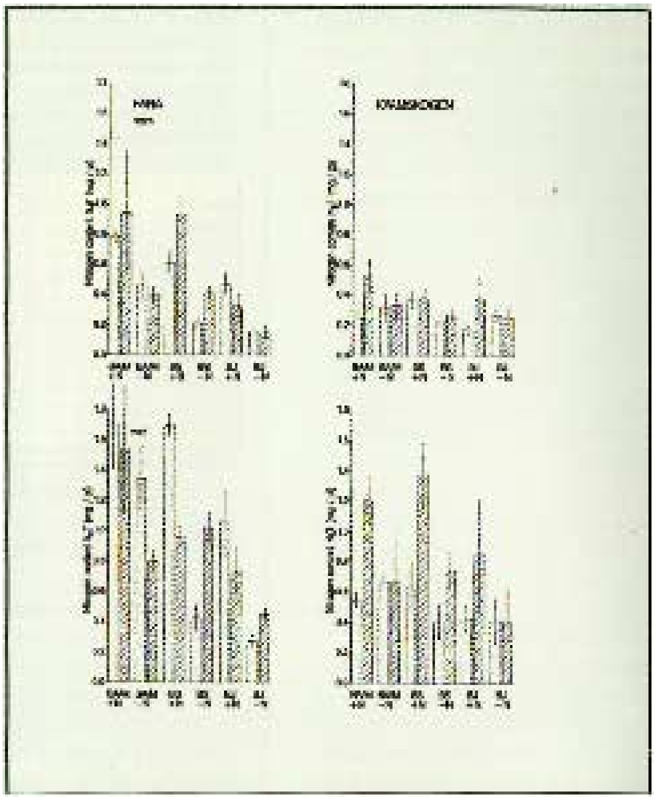

Figure 2
Total nitrogen content of stem (NST) and root (NRT) tissue in mg/plant in fertilized (+N) and non-fertilized (-N) birch seedlings grown for three months at Fana (50 m) and Kvamskogen (450 m). Some plants (open columns) are harvested before leaf fall (14.9.87) and some (hatched columns) after (25.10.87). Means of five replicates with ±2 s.e.

A comparison between populations shows that there was relatively more alternative respiration in leaves from the northern birch population than in leaves of the southern lowland population at low nutrient levels. In stem and root tissue the proportion of alternative and normal growth respiration was about the same level in all three populations. The suppression of leaf growth in arctic ecotypes is a particularly useful adaptation (Bliss 1971) in an environment with a long, cold and dark season.

Beevers (1970) demonstrated the occurrence of an alternative dark respiration pathway in ageing tissue. The high proportion of alternative respiration in northern population (BJ) leaves at low nutrient levels may therefore partly be explained by early ageing and partly by the overflow hypothesis, i.e. that arctic ecotypes use the alternative pathway to remove excess assimilates thus avoiding undesirable growth in aboveground tissue.

Conclusions

In response to the questions put forward in the introduction, the results support the hypothesis that Betula pubescens has evolved alternative respiration as an important growth-regulating mechanism (cf. Lambers 1980). At low nutrient levels there was a depression of dark respiration in leaves and stems, and most of it was alternative respiration, i.e. not linked to ATP production. The tendency was strongest in the subarctic birch population, indicating that northern ecotypes are more adapted to low-growth strategies than their southern relatives (cf. Kallio 1984, Chapin 1980). Low temperatures seemed to increase the alternative respiration rates in leaf and

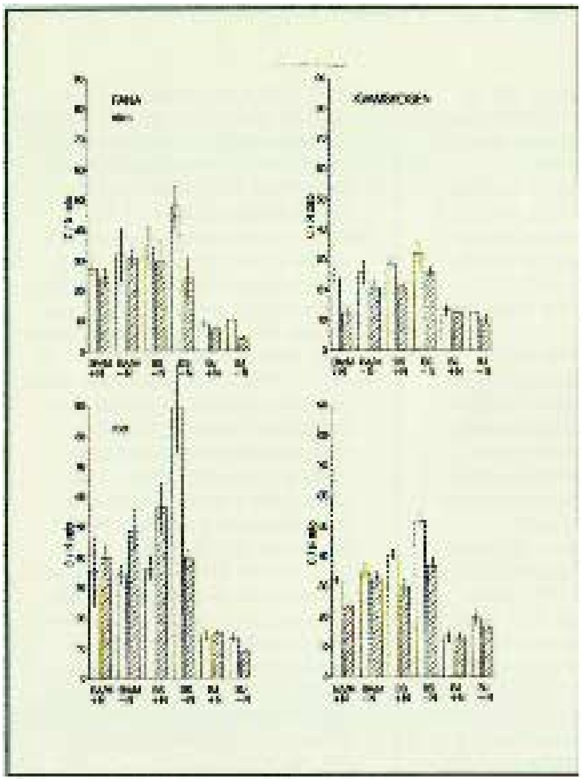

Figure 3
C/N ratios between non-structural carbohydrates and total nitrogen content in stem and root tissue of fertilized (+N) and non-fertilized (-N) birch seedlings grown for three months at Fana (50 m) and Kvamskogen (450 m). Some plants (open columns) are harvested before leaf fall (14.9.87) and some (hatched columns) after (25.10.87). Means of five replicates with ±2 s.e.

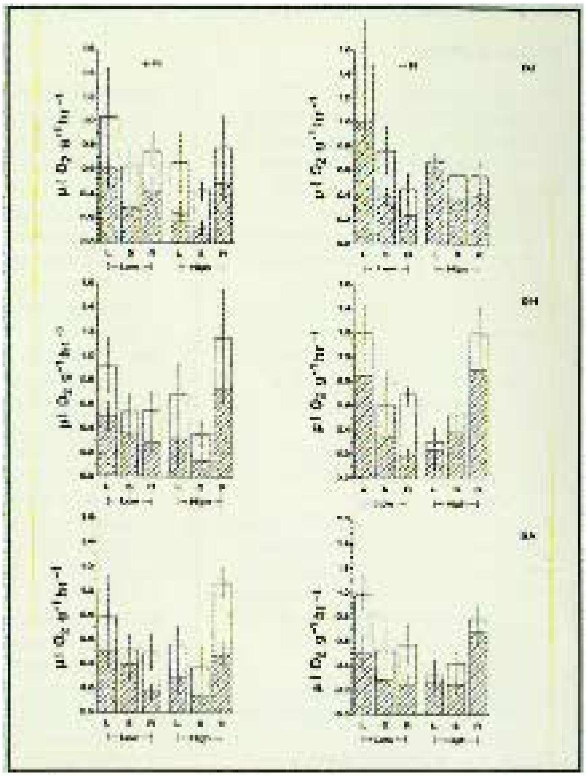

Figure 4
Dark respiration rates (µl O_2 g^{-1} hr^{-1}) in mature leaves (L). 4 mm stem segments (S) and roots (R) of fertilized (+N) and non-fertilized (-N) birch seedlings, grown for two months at high and low temperatures (see Table 2b). The respiration rates are measured with (hatched) or without cyanide and averaged over SHAM concentrations, with ±2 s.e. on the total cyanide-resistant respiration values.

stem tissue with a corresponding decrease in root tissue, indicating preference for root growth at low temperatures. This is a useful adaptation, since it would increase the capacity of roots for absorbing nutrients from the soil and restoring the balance between source and sink (cf. Thornley 1972).

A substantial part of the nitrogen in roots of fertilized plants was translocated back to the stems in fall, indicating secondary growth, while root growth was preferred in non-fertilized plants and at high elevations (low temperatures). The experiment seemed to confirm the observation made by Chapin (1980) that plants from high latitudes and altitudes tend to keep a high nitrogen concentration in their tissue when being deprived of nutrients. The highest ATP-linked growth respiration rates were found in birch seedlings from high elevations at southern latitudes (SH), as a metabolic compensation to a climate where light conditions are favorable for photosynthesis, but where the growing season is relatively short (Crawford 1989). The increased competition in southern vs. northern habitats, and at higher temperatures are reflected in the higher shoot/root ratios in southern ecotypes and the general 1- 5 °C higher optimum temperatures in all three populations for stem elongation rates than for leaf growth (Skre 1991 b).

In total, the existence of an alternative respiration pathway as a growth-regulating mechanism, maintaining the balance between nutrient absorption in roots and carbon fixation in leaves (Thornley 1972) is strong support for dark respiration being a major limiting factor at low temperatures.

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ANDERS BRYN, ANN NORDERHAUG,
AND KAROLINE DAUGSTAD

Re-growth effects on vascular plant richness in Norwegian, abandoned summer farm areas

SAMANTEKT
Svæði á mörkum fjalllendis og láglendis eru mikilvæg fyrir afkomu landbúnaðarvistkerfa á Norðurlöndum með því að veita bændum og búfé þeirra líffræðileg gæði. Í þessari rannsókn á sumarbýlaþyrpingum á mörkum fjalllendis og láglendis sem eiga 4-5000 ára landnýtingarsögu var könnuð tegundafjölbreytni háplantna eftir að býlin höfðu verið yfirgefin. Þrjú framvindusvæði voru skilgreind, kortlögð með GIS og notuð sem einingar í grasafræðilegar kannanir. Það kom í ljós að skráð áhrif endurvaxtar á fjölbreytileika plantna voru háð því hvaða rúmlægi kvarði var notaður, og að tegundafjölbreytni plantna jókst yfir lengra tímabil. Þegar endurvöxtur landslags á sumarbýlum heldur áfram, rýrnar bæði líffræðilegt og menningarlegt gildi þeirra. Í tengslum við aukna plöntun trjáa á Íslandi gæti átt sér stað samskonar rýrnun á líffræðilegum fjölbreytileika.

Since the Iron Age and up to this century summer farming has been an important and integrated part of Norwegian husbandry (Kvamme and Norderhaug 1999). The summer farm system was based on the need to utilize the resources of the outfields. The mountain summer farms had three main functions: (i) To provide summer pastures for the animals in the outfields near the summer farm, (ii) to be a production place for milk and milk-products, (iii) to serve as a base for collection of winter fodder.

Norwegian summer farming had its golden period in the middle of the 19th century, and in 1850 about 53 000 Norwegian farmsteads had summer farms in use (Reinton 1961). The number, however, decreased towards the end of the century, and this process has continued throughout the 20th century. In 1999 only 1738 summer farms were in use (Statens Kornforretning 2000).

Grazing by different domestic animals affected large areas and formed the summer farm landscape in combination with mowing of in-fenced areas, forests and mires, collection of various other types of fodder (branches, leaves, lichen, etc.) and forest logging.

The decrease in summer farming has permitted a large-scale re-growth and secondary succession of mountain birch forests in Norway (Aas and Faarlund 1995, Austrheim 1998, Daugstad 2000). The consequences of this re-growth for the summer farm landscape and vascular plant species richness, exemplified with results from a study in Grimsdalen, southeast Norway, is discussed in this paper.

Study area and methods

In Grimsdalen, Dovre municipality, summer farming is a more than 400 years old tradition. In the 1930s the utilisation period at the summer farms, however, decreased by three months, and from the 60s until the 80s the summer farms were abandoned, except for three summer farms still in use. The ceasing of felling and mowing, and reduction in grazing have resulted in a large-scale re-growth of birch forest.

The investigated plots presented in this paper, is situated around three abandoned clusters of summer farms. They are located on basic rocks (Pedersen 1979) and all sites are south-exposed and situated between 940 and 1060 meter above sea level. Average temperature during the three warmest months is 9°C, e.g. well below the potential subalpine birch forest limit in this area and just above the potential Scots pine forest limit (Moen 1998). The annual precipitation amounts 430 to 550 millimeters, most of it as summer rain.

Three types of dry to mesic secondary birch forest succession zones were defined: (i) Seminatural vegetation without trees but with a scattered bush-vegetation. This zone is still influenced by some domestic grazing, (ii) young forest, 10 to 40 years old, (iii) old forest of the age 40 to 70 years. Within these succession zones the number of vascular plant species were noted for two plot sizes:
(a) 4 m^2 (small-plots) and (b) between 1.2 and 4.3 ha (large-plots) in a nested design. Totally 27 large-plots were sampled, 9 within each succession zones, and 5 small-plots randomised within each large-plot, giving a total of 135 small-plots.

Number of vascular plant species within a small-plot is defined as α-diversity (Whittaker 1972). γ-diversity is defined as the number of vascular plants found within a large-plot. The amount of change or turnover of species between small-plots is defined as β-diversity (Wilson and Shmida 1984).

Results

Differences with regard to plant species diversity between the three succession zones depended on the spatial scale studied. On a large spatial scale i.e. looking at the γ-diversity, there were significant differences between the three succession zones (Table 1). A total species pool of 253 vascular plants was found in the plots, and most plants were found around all three summer farm clusters (58.1%), whereas 17.79% and 24.11 % were found around two and one summer farm cluster respectively. Comparison on a small spatial scale shows that the α-diversity was lower in the old forest than in the two other succession zones. Of these, young forest had the highest α-diversity, but not significant higher than for seminatural vegetation.

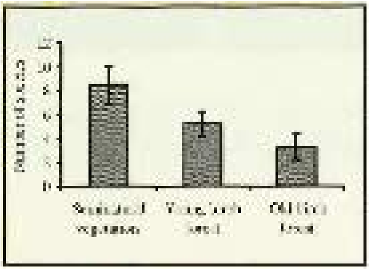

Figure 1. Arithmetic average of annuals and biennials in 27 large-plots, 9 from each succession zone. Confidence intervals at α<0.05.

The distribution of different functional plant groups also varied between the three succession zones. Annuals and biennials were clearly favoured in the seminatural vegetation (Figure 1). Other functional plant groups favoured in this zone compared with the other two zones, were alpine plants, lowland thermophilous plants and antropochores (Bryn 2000)

Table I. Arithmetic averages and confidence intervals (α<0.05) for three variables and significant differences for one-way ANOVA and Tukey HSD post hoc test (P<0.01). Tests were performed in SPSS 10.0.

	Seminatural vegetation	Young birch forest	Old birch forest
Area in m^2 (large-plots)	3174 ± 361	2654 ± 405	2917 ± 277
γ-diversity	113.7 ± 8,5*	85.4 ± 5.4*	63.9 ± 10.1*
α-diversity	20.622 ± 2,288	21.889 ± 1.704	17.356 ± 1.499*

* = significantly different from the other groups.

Discussion

The activities connected to summer farming created an open landscape and seminatural vegetation types with characteristic physiognomy and species composition. The clearing of birch forests resulted in an almost treeless landscape even several kilometers from the summer farm locality and several hundred vertical meters. In Grimsdalen the actual forest-limit was suppressed 300 vertical meters. Also in the municipality of Lærdal, West-Norway, the forest-limit was suppressed about 329 vertical meters around summer farms (Ve 1940), and in Øystre Slidre municipality, Oppland county, almost 25% of the areas below the potential forest-limit was cleared because of summer farming (Axelsen 1975). In Nes municipality, Buskerud county, the forest was not suppressed more than about 150 vertical meters, but the tree-less area covered several square kilometers around the summer farm villages (Rukke 1996).

In the 19th century, when the population pressure was considerable and the summer farming was at its height, Norwegian scientists claimed that the utilization was too intensive and the pressure on the vegetation critical (Jensenius 1872). They pointed out that the production was lowered due to too intensive grazing, and that summer farming was delaying the development of agriculture in Norway.

Today the birch forest is recapturing large subalpine areas previously used for summer farming in Norway. In Grimsdalen the area of birch forest has increased by approximately 60% since 1930 until 1997. In Budal, Sør-Trøndelag county, approximately 60% of the area that was covered with seminatural vegetation in 1963 now consist of early succession birch forest (Olsson et al. 2000). The heathlands in Sjodalen, Oppland county, is reduced by 70% in the same period, now covered by woodlands (Olsson et al. 2000). The ongoing rise in forest-limits around former summer farms in Norway is in other words a natural response of reduced felling, grazing and mowing. However, one should also consider that climatic changes may speed up this process (Aas and Faarlund 1995).

The large and visible landscape changes are not the only results of the abandonment of summer farms and the following re-growth. As shown in the Grimsdalen-study, this process also effects the biodiversity of the summer farm landscape. According to Kjelland-Lund (1992), about 350 vascular plants have their main Norwegian distribution in seminatural vegetation types. Several investigations also show that summer farming has increased biological diversity in subalpine areas (Olsson et al. 1995, Austrheim 1998, Lunnan et al 1999, Bryn 2000). Antropochores are found there either as a response of active cultivation or random dispersal by domestic animals (hooves, fur or dung) or other transport mechanisms. Small alpine species seems to fit into the subalpine seminatural vegetation due to lower competition and abundance of light. The clearing of the birch forest has probably created dispersal-corridors for these species from higher altitude down to the summer farms at lower elevations. Also lowland species exist in the summer farm landscape, probably explained by higher radiation, more nutrition and less competition.

The vascular plants in the seminatural vegetation are usually adapted to a certain disturbance regime, and many plants are tolerant to trampling, grazing and/or mowing. Plants with a short life cycle (Figure 1) are probably more abundant in the seminatural vegetation as a response of the disturbance regime and favourable light conditions (Bryn 2000).

Summer farm landscapes embodies both natural and man-induced gradients for environmental factors like light, wind, radiation, moisture, snow-cover, nutrients, birch forest successions, vegetation cover, biodiversity, disturbance etc. The man-induced gradients reflect the decrease in human induced disturbance and influence with increasing distance from the summer farm (Vandvik 1995, Bryn 2000). These man-induced gradients, operating on different spatial and temporal scales provide living conditions for several functional groups of organisms normally not found in undisturbed subalpine birch forest.

As the data from Grimsdalen shows, however, the results of biodiversity studies depend on both temporal and spatial scale (Table 1). The α-diversity, i.e. the diversity on a small spatial scale, is highest within the young birch forest, but decreasing to the lowest level in old birch forest. The γ-diversity i.e. the diversity on a large spatial scale, is highest within the seminatural vegetation decreasing with proceeding succession towards old birch forest.

The high α-diversity of the young birch forest is probably explained by spreading of "re-growth-species" and colonization of the small-plots (Huston 1994), while some seminatural species are still existing there. The β-diversity is, however, higher in seminatural vegetation compared with subalpine birch succession forest (Bryn 2000), indicating higher species turnover between the small-plots and thus more heterogeneity in seminatural vegetation.

Scaling up the spatial dimension confirms the impression of higher diversity and heterogeneity in seminatural vegetation. The γ-diversity in the seminatural vegetation includes 92% of the species existing in the two forest succession zones, in addition to 50 plant species exclusively found in seminatural vegetation (Bryn 2000). High γ-diversity in the seminatural zone (Table 1) may also be explained by high heterogeneity. Seminatural vegetation is a result of a complex combination of biotic and abiotic factors, management practice, management intensity and management continuity, resulting in a numerous variation of the species composition (Hughes and Huntley 1988, Norderhaug et al 2000). When for example the grazing pressure is light, the domestic animals will graze certain areas harder than others and also leave some nearly untouched (Nedkvitne et al. 1995). This may give plots with different species composition even within small areas of seminatural vegetation.

To give a correct picture of the variation and change in vascular plant richness after abandonment, it is therefore important to sample on different spatial scales. The Grimsdalen-study shows that light and space are of great importance for the species composition of seminatural vegetation. The study, however, also shows that the importance of different environmental factors for structuring the vegetation depends on the spatial scale. The importance of environmental factors and effect of the re-growing process after abandonment on rare plants and seminatural vegetation types was best shown by a large-scale approach (Bryn 2000). A one-scale study of the α-diversity would not revealed what was really happening and the serious consequences for biodiversity of the re-growth.

Prospects of re-growth in summer farm areas and tree-plantation in Iceland

As most summer farms are abandoned and the grazing pressure is reduced, the subalpine birch forest is claiming ground by succession processes. The habitats for antropochores, small alpine plants and lowland plants are reduced by re-growth, and the biological diversity in the summer farm landscape is lowered all over Norway.

Whether forest re-growth and tree-plantation will have the same effect on vascular plant diversity in Iceland as in Norway is unknown as far as we know. In Iceland the species pool is lower (Kristinsson 1987), the climate more oceanic, the grazing widespread and more dominated by sheep and horses. We should, however, be aware of the danger of loss in biological diversity if proper planning and management are not implemented. In the other Nordic countries the importance of the cultural landscapes for many red list species is given increased priority. The seminatural vegetation also demonstrates cultural aspects and values. Historical interesting seminatural habitats in Iceland that should be taken into account in this connection was described by Einarsson (1987).

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FRANS E. WIELGOLASKI

Field- and bottom layer vegetation mat transplantation:

A method to simulate possible effects of climate change?

SAMANTEKT
Þökum úr bláberjalyngsmóum var umplantað yfir í þurra fléttuheiði, en þökur úr henni voru færðar yfir í bláberjalyngsdæld 100-200 m í burtu. Breytingar á gróðrinum voru skoðaðar eftir mislangan tíma.
Eftir 4 ár var minna en 20% af bláberjalynginu á lífi í fléttuheiðinni, en eftir 9 ár einungis 10%, og fimmtán árum eftir umplöntunina voru engir lifandi sprotar af bláberjalyngi eftir í hinni þurru fléttuheiði. Á runnfléttunni *Cetraria nivalis* (maríugrös), sem venjulega vex á vindsorfnum hæðarbrúnum, gulnaði þalið hins vegar strax einu ári eftir umplöntun í votari bláberjalyngsdæld. Þekja maríugrasanna minnkaði niður í 3-4% eftir fjögur ár, og var einungis 1 % eftir níu ár, borið saman við þökur sem var umplantað innan sama svæðis. Breyting á þekju annarra tegunda við mismunandi umplöntun var einnig greinileg, en þó minni.

Votara loftslag með meiri snjó- og íshulu og styttra vaxtartímabili getur haft svipuð áhrif og umplöntun á gróðurþökum úr þurri fléttuheiði í bláberjalyngsdæld með lengri snjóþekju, líkt og kom fram með dauða maríugrasanna. Aftur á móti geta loftslagsbreytingar sem valda minni snjóþekju, kaldari vetrum og meiri þurrki haft svipuð áhrif og sést á umplöntun bláberjalynggróðurs í þurra og opna fléttuheiði.

The climatic growth conditions vary strongly over small distances in mountains. Particularly, this is true for the snow cover and the soil moisture. Therefore, it may be possible to simulate the effect of climatic changes by reciprocal transplantations of the vegetation between nearby sites of different soil moisture and snow cover.

In most cases transplantation studies have been carried out on single plant specimens, although in some cases populations are studied (Clausen *et al.,* 1948; Mooney and Billings, 1961, McGraw, 1987). The reason is that in most natural plant communities it is not possible to transplant the whole community because of the size of the plants both above and below ground. In many types of arctic, alpine and sometimes subalpine plant communities, however, this might physically be done because of the small plants found in the field and bottom layer.

As a working hypothesis in the present study it was expected that the species growing in a sheltered snow bed would be more strongly influenced by transplantation to a winter cold and summer dry wind exposed heath, than the species naturally growing at that community, when placed in a more sheltered and moister snow bed. It was also expected that the recovery would be slower in the more strongly stressed windswept heath than in the snow bed.

Material and methods

Vegetation mats of two types of low alpine plant communities at the mountain plateau Hardangervidda in southwestern Norway (latitude 60°N, elevation 1200m a.s.l.) were chosen in the present study, but similar transplantations could also been done in the subalpine mountain birch forest. One community was an oligotrophic heath dominated by blueberries (a Phyllodoco-Vaccinion myrtilli community), one of the most common communities in the region. It is found where there is some snow protection from the lowest winter temperatures and not too dry soil in the summer. On the other hand the vegetation period cannot be too short, which means that this type is missing also in extreme snow beds. The other community chosen was a typical oligotrophic lichen heath (an Arctostaphyleto-Cetrarion nivalis community), common at dry, wind swept, winter cold ridges.

The two communities thus represent various climatic conditions, although the horizontal distance between them in the field was only 1-200m. It was

Table 1. Relative cover (%) July 1991, Hardangervidda, for some plant species showing strong changes between plots after transplantation. (Benedict and Wielgolaski 1992).

Plant species	***Lichen heath***		***"Blueberry" community***	
	Selt-transpl.	Transpl. to "blueberry" community	Self-transpl.	Transpl. to lichen heath
Vacc. myrtillus	0	0	9.42	1.00
Vacc. vitis-idaea	19.00	2.42	0	5.42
Desch. flexuosa	0	2.50	9.75	3.42
Festuca ovina	5.73	4	0	0.75
***Dicranium* coll.**	1.10	6.92	16.25	11.50
Cetraria nivalis	22.10	0.17	0.17	7.83

expected that reciprocal transplantations between the two communities within some years would visualise changes in the taxonomic composition. In that way the studies could give indications on possible vegetation changes by climatic variation, for instance due to the greenhouse effect by CO_2 increase. The response of the various plant species does not reflect only the influence of each stress factor before and after the transplantation, but it also reflects the internal changes in the competition within the community.

The two communities chosen in the studies are both low growing without deep roots. Therefore, the mats could relatively easily be moved from one place to another without too much destruction of the plants. About 10 cm thick vegetation mats in six replicates were carried between the sites in 75 by 35 cm styroform boxes. Mats of similar size were also transplanted within each of the sites to see the effect of destruction of tops of roots by the transplantation itself in comparison with vegetation on untouched plots. Non-destructive samplings by percentage coverage of the various plant species were carried out at the time of seasonal maximal above ground biomass the first year of study, after four years and after nine years (Wielgolaski and Benedict, 1986; Benedict and Wielgolaski, 1992). Some rough estimates were also done after 15 years.

Results and discussion

Less than 20% of the plants of *Vaccinium myrtillus* (blueberry) transplanted to the lichen heath were alive after 4 years and even half of that 9 years after transplantation, given as relative cover (Table 1). 15 years after transplantation all blueberry plants transplanted to the lichen heath were dead. The reduction also in biomass of the species by transplantation was strongly significant both when compared with the control plots and with the selftransplanted ones. The biomass of V. *vitis-idaea* moved from the lichen heath to the blueberry heath was also strongly reduced after 9 years. The cover of the species at that time was less than 13 % as high in the transplanted as in the selftransplanted plots (Table 1). Explanations for the reduction in V. *myrtillus* by transplantation may be both the draught and the windy and cold, poorly snow covered lichen heath. The death of V. *vitis-idaea* at the blueberry community was more surprising, but may have something to do with the wetter soil conditions at the site.

The two grass species *Deschampsia flexuosa* and *Festuca ovina* showed a similar, but less dramatic response to reciprocal transplantations between the sites. Normally the first species mentioned is favoured in areas of good snow cover, the second in dry, wind blown areas. Both species, however, seemed to survive relatively well 9 years after transplantation to other conditions. About 1/3 of D. *flexuosa* (measured as cover or biomass) survived 9 years after transplantation from the blueberry heath to the wind blown lichen heath, while F. *ovina* survived well after transplantation to the wetter blueberry community. However, the last species showed a considerably weaker flowering percentage when transplanted from its natural site. This may probably indicate a weaker fitness to the more sheltered conditions.

Also some of the other vascular plants in the study not shown in the table, gave interesting responses to the transplantations. The dwarf *Salix,* S. *herbacea,* was not naturally found in the plots at the lichen heath, but survived well after transplantation from the blueberry heath even 15 years after transplantation. However, S. *herbacea* transplanted to the lichen heath did not flower. This may indicate that good establishment was a problem for the species at the wind blown site, although it survived well in the lower competition pressure after transplantation.

Lowered competition was probably the reason why *Trientalis europaea,* as well, showed a good survival in the lichen heath after transplantation from the blueberry community in spite it was not naturally growing at the wind swept site. It also showed a surprisingly high flowering percentage at the lichen heath which may have been caused by a lower competition for nutrients after reduction in the amount of V. *myrtillus* and D. *flexuosa* by transplantation.

A third species of vascular plants obviously favoured by lower competition after transplantation was *Carex bigelowii.* There was a clear increment both in biomass and relative cover of this species after transplantation both from the blueberry community to the lichen heath and vice versa. Also the flowering percentage of the species was highest in the transplanted plots.

Among the cryptograms the lichen *Cetraria nivalis,* normally growing at wind swept dry ridges, seemed to have very strong requirements just for such conditions. By transplantation to the moister blueberry heath (sometimes ice covered in winter) it showed a decrease in chlorophyll and a yellowing of the thalli already one year after they were moved, may be due to lack of oxygen. In winter relative cover of the species at the blueberry community 4 years after transplantation was 3.4 % of the cover in the selftransplanted plots at the lichen heath, reduced to 0.75% after 9 years as seen in Table 1, and the biomass was reduced to approximately zero. In the plots transplanted from the blueberry to the lichen heath on the other hand considerable amounts of C. *nivalis* had blown into the plots after 9 years, approximately 1/3 of the amount at the selftransplanted plots (Table 1) in the blueberry community.

Also most of the *Cladonia* species (and particularly the reindeer lichens) showed reduced amounts after transplantation from the lichen heath to the blueberry community, while pieces of the thalli even of these species blowed into the plots by the reciprocal transplantation. Denser and lower species of lichens, for instance *Ochrolechia frigida, Cladonia coccifera* (and similar species), as well as the species *Cetraria islandica,* showed a wider tolerance to the environment and were relatively stable elements of the plots in both communities.

Bryophytes are generally more common in the moister blueberry community than at the wind swept ridges. In the plots transplanted to the blueberry heath *Dicranum* increased in cover after 9 years (Table 1), but the plants were still small. *Polytrichum* had also started some establishment after the transplantation to the moister environment, but less than expected. By the reciprocal transplantation to the lichen heath there was a limited reduction in mosses after 9 years.

Liverworts in the study (data not given in Table 1) strongly showed their need for moist condition by a reduction to nearly zero, particularly in the biomass, by transplantation from the blueberry to the lichen heath. By the drier surface conditions because of reduced plant cover after transplantation from the lichen heath to the blueberry community only small amounts of liverworts were found even after transplantation in that direction.

Generally the results mean that the hypothesis of quicker reestablishment of vegetation at the blueberry community than at the lichen heath did not seem to be true. Reinvation of woody plants as V. *myrtillus* and *Empetrum herma-phoditum* may not take place in low alpine or subalpine areas through 10-20 years, showing the slow recovery in mountains.

The transplantation studies at Hardangervidda show impacts of importance by eventual changes in the climate in polar-alpine and subpolar- subalpine regions (Callaghan *et al.,* 1995; Crawford, 1997; Grabherr *et al.,* 1994; Guisan *et al.,* 1995; Hollister, 1999). A main conclusion is that generalizations about responses in plant communities on environmental changes as a whole must be drawn by care. A response seems very much to be dependent on the various species and their growth requirements. Competition seems to be extremely important for the presence and vitality of some species. Important changes in the species composition may also take place because of a combination of effects by changes in competition and in environmental factors.

Changes in the climate causing less snow cover, colder winters and drier conditions may cause effects of the type found by transplantations from the blueberry community to the lichen heath. Species normally bound to the blueberry heath, for instance V. *myrtillus,* will strongly decrease or disappear, when moved to a wind blown site. Similarly, a reduction in D. *flexuosa* and mosses may be observed, while V. *vitis-idaea* and reindeer lichens (included C. *nivalis)* may increase, the lichens mainly because of wind blowing pieces into the plot, when transplanted from a more snow covered site.

Climatic changes simulated by reciprocal transplantations from the lichen heath to the blueberry community generally seem to be more serious to the vegetation. This indicates that a wetter climate with more snow and ice crusts and shorter vegetation periods, but with better protection against low winter temperature, will have important impacts. First of all many arboreal lichens may be killed, while V. *vitis-idaea* and F. *ovina* are reduced. Due to the lower competition, *Carex bigelowii* may grow well, while establishments of most other vascular species (except D. *flexuosa)*, and to a lesser extent some mosses, seem to be slow.

Acknowledgement

The planning of the studies and the field work were carried out together with Dr. Faye Benedict. The author thanks her for good collaboration in all the work.

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SOFFIA ARNÞÓRSDÓTTIR AND ÁLFHEIÐUR ÓLAFSDÓTTIR

The role of herbivory for downy birch growth and resistance in an Icelandic shrubland

SAMANTEKT
Þessi rannsókn beinist að samspili jurtaætna og íslenska birkisins *(Betula pubescens)* á athugunarstað í úthafsloftslagi á Suðvesturlandi. Birkið er undirstaða mikilvægra fæðukeðja dýra hérlendis. Skógurinn er framleiðinn mælt í lífmassa laufa og fræframleiðslu. Sérhæfð skordýr og hryggdýr. sem éta lauf og fræ, eru mikilvægar jurtaætur í þessu kerfi, meðan önnur dýr forðast beiskjuefnin í birkifræjum og laufum. Skordýrafaraldrar á íslensku birki hafa verið skráðir af náttúrufræðingum á tuttugustu öld og á fyrri öldum. Hefðbundin sauðfjárbeit á sér enn stað í náttúrlegum birkiskógum þótt tekist hafi að friða sum skógarsvæði.

Það er mikilvæg spurning hvaða áhrif sauðfjárbeit hefur á vöxt, æxlun og skordýraviðnám birkis. Sauðfé kýs oft ungt birki fram yfir annan gróður. Sókn sauðfjár er meiri í birki og aðrar viðarkenndar tegundir þegar lítið framboð er á jurtkenndum kjörplöntum. Samanburður er gerður milli birkiplantna af mismunandi aldurshópum. Í tilraunum voru könnuð áhrif beitar að vorlagi og mismunandi beitargerðar fyrir endurvöxt birkis. Athuganir voru gerðar á samspili birkis og birkifiðrilda, aðallega *Epinotia solandriana* en einnig *Operophtera brumata,* en ummerki um lirfurnar sjást sem vefhýsi á laufunum.

Líkt var eftir beit að vorlagi með því að klippa endabrum á eldri plöntum Í Heiðmörk. Þegar hermt var eftir beitinni dró úr nýliðun laufa og bruma. Laufgun birkisins varð þegar lofthiti hafði verið yfir frostmarki í þrjár vikur, og fljótlega eftir laufgun varð mikil fjölgun á vefhýsum trjámaðka í laufinu. Klippingar á brumum voru skaðlegri fyrir fræplöntur en klippingar á laufum. Áhrif klippinga á brumum og laufum voru merkjanleg á hæðarvöxt fræplantna.

Langtímamarkmið beitarrannsókna á íslensku birki er að fá samanburð milli svæða, þar sem birkið vex í ólíkum jarðvegi og loftslagi.

This paper centres on the diverse effects of herbivory on downy birch *(Betula pubescens)* in Iceland. The goal is to examine the interaction of herbivores and downy birch, especially, how grazing affects the plants and how grazing may interact with plant resistance to insect herbivores. At the same time it is important to examine the phenology of the plants in relation to existing weather patterns. The present study, adds to the knowledge on herbivory effects on birch in a northern oceanic climate.

In the neighbouring countries, direct negative effects of herbivory on birch growth and reproduction are sometimes reported (Hoogesteger and Karlsson 1992, Karlsson et al 1996). However, many factors may influence the interaction of birches with a diverse set of herbivores (Mahdi and Whittaker 1993, Suomela and Neuvonen 1997). Ungulate browsing may reduce growth and be fatal for birch seedlings (Pigott 1983). Among the herbivores feeding on downy birch are insects and large mammals that feed on the foliage, while specialist birds and insect feed on the catkins (Atkinsson 1992).

In Iceland, downy birch forms extensive shrublands that sustain important animal food webs. The birch shrublands are productive in terms of leaf biomass and seed production. Sheep may include birch in their diet, often preferring birch to other available vegetation. Some studies have addressed the importance of sheep grazing for the regeneration of birch seedlings and recovery of birch shrublands (Þorsteinsson and Ólafsson 1967, Aradóttir 1991). Sheep grazing is still permitted on some native birch shrublands while other shrublands are protected (Garðarsson 1996). Downy birch, especially young plants and new growth, may be included in sheep diet at times when their preferred grasses and forbs are unavailable. Other domestic mammals may cause injury to birch, especially horses, that may trample on seedlings or chew on the bark of mature birches. Sheep grazing may affect the growth, reproduction and insect resistance of birch in Iceland. The most important vertebrate seed feeder in Icelandic birch forests is the redpoll *(Carduelis flammea)*, while other birds feed on birch seeds to a lesser extent.

The natural history of the insect species feeding on birch in Iceland is quite well recorded (Ottósson 1982), including information on moth species (Ólafsson and Björnsson 1995) that feed as caterpillars on the birch. Among the caterpillars that may cause the greatest damage are two species of tortricid moths, *Epinotia solandriana* and *Acleris notana*. Two species of geometrids are also common, *Operophtera brumata* and *Rheumaptera hastata,* while the third geometrid, *Erannis defoliaria,* is common only in southeast Iceland. The noctuid caterpillar, *Diarsia mendica,* feeds opportunistically on birch, but more commonly feeds on other dwarf shrubs, including the related dwarf birch *(Betula nana*). Outbreaks of insects on downy birch in Iceland are reported by biologist in this and past centuries. Caterpillars may cause widespread damage to both buds and leaves of birch in Iceland, but the nature and scale of insect outbreaks is likely different from the situation in the neighbouring countries.

The experiments described here explore the regrowth of young and mature plants after simulated early season grazing. In addition, the field study addresses the importance of early season grazing for the resistance of birch to insects.

Materials and methods

A field study was conducted in 1998 in Heiðmörk (64°N, 21°W), a study site protected from sheep grazing, where downy birch forms scattered shrublands. Most of the birches at the site are mature plants, seedlings were rare during the study. During the summer caterpillar infestation of the plants was high, as shown by a high number of folded leaves called caterpillar tents. *Epinotia solandriana* caterpillars were the most common, but *Operophtera brumata* also occurred. The ground vegetation consisted of dwarf shrubs, forbs, graminoids and mosses.

A group of forty mature birches were assigned to the study. The following factors were examined: (1) The effect of simulated grazing on birch growth, and (2) the effects of simulated grazing on insect resistance, as estimated from the occurrence of caterpillar tents. On mature birch, apical buds were removed before bud burst, while control plants were untreated. The bud removal simulated early season browsing by sheep on mature plants. Individual birches on each plant were randomly assigned to the study. All apical buds were removed on the assigned branch and adjacent branches, removing a total of forty apical buds on each plant. Regular recordings were made every other week on branch segments originally consisting of approximately twenty buds, counting the numbers of buds, leaves, shoots and caterpillar tents.

Few seedlings grew at the study site, but experiments on seedlings were made in outdoor plots at the nearby Icelandic Forest Research Station, Mógilsá. This allowed an indirect comparison of the herbivory tolerance of young as compared to mature birches. Cutting treatments simulated grazing effects on leaves and buds in the early season.

Sixty birch seedlings were originally raised from seeds in individual plant pots in unheated greenhouses and subsequently transferred to open plots in climate conditions similar to the nearby Heiðmörk area. Five trays, with an equal number of plants in each treatment, were placed in the open plots and the trays were regularly rotated to ensure uniform conditions. There were two cutting treatments and an uncut control. The plants were designated to different treatments: partial foliar damage (1/4 of every other leaf), bud damage (every other bud removed), and control. Regular recordings were made every other week of seedling growth in terms of addition of leaves and buds, extension of the main shoot and individual branches. The experiment was run during the summer.

The analysis of data was made using a repeated measures analysis for multifactor experiments (Potwin et al. 1990, Winer et al. 1991) and the statistical package SPSS 8.0 for Windows.

Results

Apical bud removal on mature birch in the early season reduced bud production as the season progressed (Pillai´s trace $F_{4,29}$ = 5.126, P<0.01, fig. 1). The treatment also reduced leaf production ($F_{1,32}$ = 9.102, P < 0.01), but no change in the effect on leaf production was detected through time (fig. 2). Budbreak occurred during a dry period when the air temperature had exceeded 10°C for three weeks. An increasing number of caterpillar tents were recorded as the number of expanded leaves increased. Simulated browsing on the plants did not affect how many caterpillar tents were added through the season (P > 0.05). There was not a strong relationship between increased leaf expansion and the maximum daily temperatures. The mean monthly precipitation was 190 mm in May, 25 mm in June,

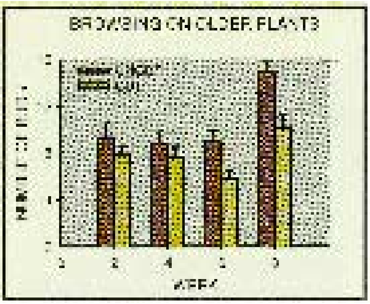

Figure 1. The mean number of buds on mature birch through the summer of 1998 in simulated grazing and control treatments. Standard errors of means are shown.

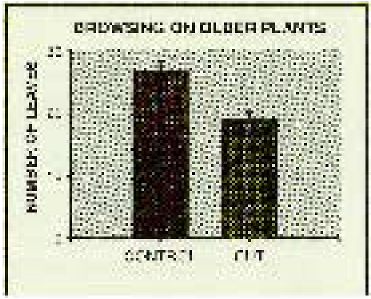

Figure 2. The mean number of leaves on mature birch in the summer of 1998 in simulated grazing and control treatments. Standard errors of means are shown.

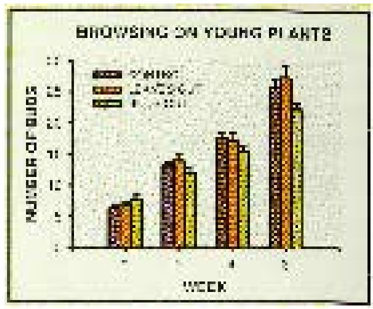

Figure 3. The mean number of buds on young birch through the summer of 1998 in simulated bud grazing, leaf grazing and control treatments. Standard errors of means are shown.

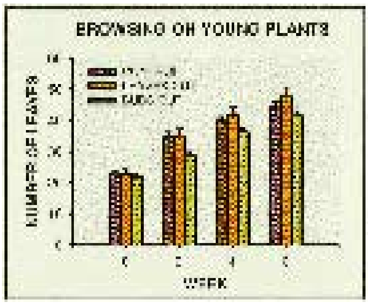

Figure 4. The mean number of leaves on young birch through the summer of 1998 in simulated bud grazing, leaf grazing and control treatments. Standard errors of means are shown.

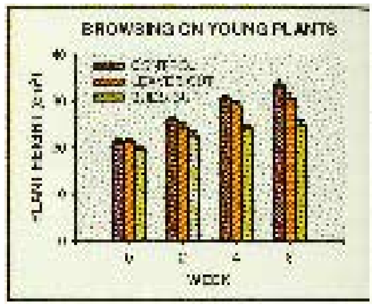

Figure 5. The mean height of young birch through the summer of 1998 in simulated bud grazing, leaf grazing and control treatments. Standard errors of means are shown.

and 69 mm in July in Heiðmörk in during the year of study, 1998. In comparisons to previous years (1993-1997) May was unusually wet whereas June and July were quite dry. The mean daytime maximum temperature was 12°C during the months of study (May-July) and maximum daily temperatures did not exceed 19°C. Monthly night time average minimum temperatures were 5°C.

Three measures of seedling growth (bud number, leaf numbers and plant height) showed an effect of treatment over time. Bud numbers remained lower through the growing season on plants that had received early season damage ($F_{Huynh\text{-}Feldt} = 3.690$, df = 6, $P < 0.01$). Similarly, leaf numbers remained lower on plant that had received early season damage ($F_{Huynh\text{-}Feldt} = 4.318$, df=6, $P < 0.01$). The response was strong to bud damage, but not detectable for leaf damage (fig 3- 4). Seedling height was reduced by bud damage and to a lesser extent by leaf damage ($F_{Huynh.Feldt} = 9.516$, df= 6, $P < 0.001$). Damage effects on height were more pronounced than damage effects on leaves and buds (fig 5).

Discussion

Downy birch responses to spring browsing at an oceanic site in Iceland are similar to what is reported from continental locations in northern Fennoscandia (Hoogesteger and Karlsson 1992, Karlsson et. al 1996). The indication is that the birch has a high ability to recover from early season browsing. Surprisingly, younger plants seem to recover more strongly after damage than mature plants.

In the present study, early season bud removal affects the growth of mature birch. However, there is no indication of altered resistance of the downy birch to herbivory. This is contrary, to the findings in comparable studies in continental Fennoscandia (Neuvonen et al. 1988) as well as studies indicating that resistance to herbivores may be mediated by biotic and abiotic stress to the plants (Mahdi and Whittaker 1993, Suomela and Neuvonen 1997).

The climatic data suggest that bud burst on downy birch in Iceland depends on constant above freezing temperature as reported in more southerly oceanic climates (Billington and Pelham 1991).

While this study reflects on the bud and leaf dynamics of downy birch, more information is needed in the future on the biomass production and leaf biochemical content of downy birch in Iceland in relation to herbivory. The long-term goal is to make important comparisons among areas where birch grows in a different soil and climate conditions. Further analysis of the data set from this study may reveal morphological responses of the, birch to grazing. The effect of caterpillars is likely subtle and will require more controlled experiments to detect.

It would be interesting to see if there is a negative effect of bud and leaf herbivory on catkin production in addition to damage caused directly to catkins by herbivores. In Britain herbivores take a significant toll of the annual catkin production (Atkinsson 1992). More work is needed on the functional ecology of herbivores and their food plants in Iceland. Future questions should address the different scales at which events occur ranging from the interaction of individual birch growth and herbivore feeding patterns, up to the larger scale questions of how grazing management and insect outbreaks affect the birch ecosystem.

Acknowledgements
Thanks to Ása L. Aradóttir. Árni Bragason, Arnþór Garðarsson, Erkki Haukioja, Kalle Lertola and Seppo Neuvonen for their encouragement and advice. People at the Icelandic Institute of Natural History, Akureyri, the Icelandic Forest Research Station at Mógilsá, and the University of Turku, Finland, facilitated this study. The project was enhanced by a NorFA Fellowship to Soffía and a Scholarship from Nýsköpunarsjóður Námsmanna to Álfheiður.

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CONCHITA ALONSO

Is plant chemistry determining mortality and dispersal of young *Epirrita autumnata* larvae?

SAMANTEKT
Það er nauðsynlegt að ákvarða þá þætti sem valda mismunandi laufskaða ef skilja á þróun varna gegn jurtaætum. Úti í náttúrunni er tvennt sem orsakar það að einstök tré verða fyrir meiri laufskaða en önnur tré sömu tegundar, nefnilega: það getur staðið undir fleiri jurtaætum, eða hver einstök jurtaæta getur étið meira magn laufa mælt í lífmassa. Mismunur í atferli við fæðunám sem ekki orsakar dauða lífverunnar mun aðallega hafa áhrif það hvað lirfustigið varir lengi og endanlega stærð jurtaætunnar, á meðan breytileiki í fjölda jurtaætna mun að líkindum ákvarða mun í laufskaða plantna innan plöntustofnsins.

Val skordýra á varpstað, og dreifing og afföll á ungum lirfum ákvarða sennilega fjölda skordýra sem nærast á tiltekinni plöntu. Það er vitað fyrir haustfiðrildið, *Epirrita autumnata,* að mæður eru ekki vandfýsnar þegar þær eru að verpa. Hinsvegar er lítið vitað um dreifingu og afföll á ungum E. *autumnata* lirfum. Hér sýni ég niðurstöður úr tveimur tilraunum þar sem svifdreifing á spunaþræði, og afföll á ungum lirfum voru athuguð á einstökum birkitrjám sem vitað var að höfðu mismunandi lífefnasamsetningu. Niðurstöður úr þessum tilraunum benda til að gæði laufanna geti haft áhrif á afföll hjá ungum E. *autumnata* lirfum, en séu ekki líkleg til að hafa áhrif á dreifingu þeirra.

Traits affecting oviposition selection, dispersal and mortality of young larvae could be considered as the most efficient plant defenses against herbivorous insects since they will determine the final number of consumers sustained and, thus, the defoliation experienced by different plants. Instead, plant characteristics modifying feeding behavior without affecting mortality of individuals (i.e., *per capita* consumption), will mostly determine affect the length of larval period and the final size of individuals that will not drastically change the defoliation of the plant in the current season. Furthermore, both aspects may be determined caused by the same factors with additive or non-additive effects, and they can also modulate the responses of the natural enemies of the herbivores (Leather and Walsh 1993, Thompson 1988a, Hunter and Elkinton 2000). Furthermore, distinguishing these different steps in the interaction between plants and herbivorous insects can be also is relevant to understand the evolution of their relationships since mother selection and young larvae selection both imply active selection by the herbivore who would in turn play the role of selection pressure on plant characteristics, whereas, survival of young larvae implies differential mortality and thus plants would be in this case the selection pressure on herbivores (Thompson 1988b). Only detailed field studies of herbivore densities and defoliation can distinguish these different sources of variation under natural conditions (e.g., Hunter et al. 1997, Hunter and Elkinton 2000). In addition, indoor controlled experiments may be useful, however, to evaluate the potential relevance of these different stages and specially to discard those with low possibilities to affect the interaction between particular species.

The interaction between the autumnal moth *(Epirrita autumnata* Bkh.) and one of its main host plants the white birch *(Betula pubescens),* has been studied from many different perspectives (Ruohomäki et al. 2000 and references therein) *Epirrita autumnata* is a univoltine geometrid species. Individuals overwinter as eggs, and the new generation hatches in spring, when synchrony with leaf flush is important for larval development (Ayres and MacLean 1987). Duration of the larval stage depends on temperature and foliage quality. The pupal mass reached at the end of larval development is a good estimate of realized adult fecundity (Tammaru et al. 1996). The short-lived adults eclose in autumn. Females do not usually fly before oviposition and they are not selective while ovipositing (Tammaru et al. 1995, 1996). Although E. *autumnata* larvae are polyphagous leaf chewers, mountain birch *Betula pubescens* subsp. *czerepanovii* (Orlova) Hämet-Ahti, due to its abundance, is their main host plant in Northern Fennoscandia (Kallio and Lehtonen 1973), where the species periodically cause severe defoliations. Mountain birch leaves contain relatively high levels of different phenolic compounds (Ossipov et al. 1997) whose quantities vary among individual trees and with leaf development (Suomela et al. 1995, Nurmi et al. 1996), and can affect E. *autumnata* performance (e.g., Kause et al. 1999). Among these phenolic compounds high gallotannin concentrations are characteristic of young developing leaves (Ossipov et al. 1997, Kause et al. 1999) and thus, they are potentially suitable defensive compounds against the earliest season leaf feeders the neonate larvae of E. *autumnata.* However, little is known about the effects of birch chemistry on dispersal and mortality of young E. *autumnata* larvae.

The dispersal of neonate larvae by ballooning has been described in some other Lepidopteran species such as *Lymantria dispar* (Lymantriidae) (Hunter and Elkinton 2000), *Operophtera brumata* (Geometridae) (Tikkanen 2000), *Orgyia vetusta* (Lymantriidae) (Harrison 1995), and *Thyridopterix ephemeraformis* (Psychidae) (Ghent 1999), in relation to host plant species, budburst phenology, natural enemies and abiotic conditions. None of these studies has tried, however, to test if larvae can use the same mechanism to discriminate conspecific plants differing in leaf characteristics other than phenology (but see Harrison 1995). Here I present results from two experiments where ballooning dispersal, and mortality of young larvae were studied in individual mountain birches known to differ in their foliage chemistry.

Materials and methods

Ballooning experiment

Ballooning studies were carried out on early June 1998 using the same 30 mountain birch trees whose leaves had been previously analyzed and tested for quality as food for E. *autumnata* larvae (Lempa et al. 2000). Two other substrates than mountain birch, a glass bar and a branch of pine, were also used to test the capability of E. *autumnata* larvae to balloon under laboratory conditions. As a standard procedure a table home ventilator (Finca©) was used to produce a continue air flow that allow larvae to escape from the host using silk filaments ('ballooning'). Both larvae found on the table and those observed while ballooning were recorded as 'ballooning' individuals. All the experiments were done at room temperature (22-23 °C). Larvae used in both experiments belonged to laboratory reared strains maintained at Kevo Subarctic Research Institute Field Station.

Fourteen neonate larvae of E. *autumnata* were placed with a fine brush at different portions of a thin glass bar in which three rubber elastic bands were placed to provided larvae with irregularities that helped them larvae to stay in the artificial branchbar. The number of larvae remaining in the bar and ballooning were recorded every five minutes for 150 min. In addition, a small portion of a pine branch was cut and placed in water. *Epirrita autumnata* larvae were transferred there and subsequently monitored recording the number of individuals ballooning. This procedure was conducted on three different dates 11, 17 and 22 of June.

On 12 June, a branch containing at least 18 short shoots was cut from every study tree (N = 30). Branches were kept in cold while collecting and immediately carried to the lab where they were placed in water to avoid desiccation of leaves. Branches were all starting to open their buds but leaves could not be observed yet. Eggs from six different broods were mixed and the hatched larvae were randomly distributed among trees. Fifteen larvae were transferred to each stembranch trying to place them around the same point, selecting some stern bifurcation if available.

Greenhouse experiment

The experiment was carried out in March 1999 at Satakunta Environmental Research Centre. I used 3 years potted mountain birch saplings obtained from seeds that were three years old at the time of the experiment. These saplings were obtained from seeds that belonged to seven identified trees whose foliage chemistry was well-known (Lempa et al. 2000). For this experiment we selected seven mother the selected trees that comprised a broad variation in concentrations of proteins and total gallotannins (Table 1). Four saplings per mother tree of similar size, phenology and appearance were used as replicates. Pots were placed on Petri dishes (12 cm diameter) containing water to avoid larval movements among plants. The system was proved to be effective for this purpose, since some of the dead larvae were found within the Petri dishes, and it was also used as watering system and its level was cheeked every day adding more water when necessary controlling the level of water daily.

Table 1. Mean concentrations (mg/g) of total phenolics, gallotannins, carbohydrates and proteins of the birch trees included within each class, number of trees in brackets. Values correspond to leaves collected in late June 1997. Different letters indicated significant differences between classes at P < 0.05 (Student-Newman-Keuls analyses).

Class	Total phenolics	Total gall0tannins	Total carbohydrates	Total proteins
Gallotannins				
High (1)	142.17 a	27.61 a	85.57 a	178.29 a
Medium (3)	117.32 a	11.79 b	113.64 a	135.75 a
Low (3)	93.78 a	2.24 c	114.09 a	128.62 a
Proteins				
High (3)	120.96 a	15.04 a	103.17 a	169.43 a
Low (4)	103.15 a	6.15 a	114.82 a	115.78 b

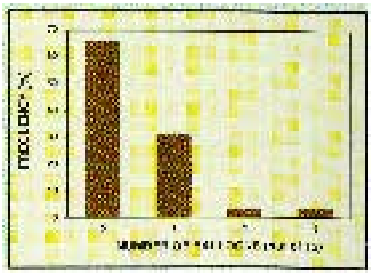

Fig 1. Percentage of birch trees from which we observed different numbers of neonate *Epirrita autumnata* larvae ballooning.

All pots were placed in 4 rows (= blocks) in the same greenhouse bench with a randomized block design and saplings from each mother-tree were randomly located within rows, separated by 10 cm, with double distance between rows.

Overwintering E. *autumnata* eggs were taken from seven different broods and placed at room temperature until they hatched. One larva per family was placed on each plant up to a total of seven larvae per sapling. Larvae were allowed to freely feed within the assigned plant. After molting to the second in star every larva was individually weighed, marked with fast drying paint, and reweighed after marking. Weight at the end of the instar was also recorded, and growth during the instar was thus estimated as the difference between final weight and weight after marking.

Data analyses

All statistical analyses were conducted with SAS-package (SAS Institute 1996).

Differences between mother trees (trees hereafter) in the proportion of larvae that ballooned or survived to the end of second instar was analyzed by fitting a Generalized Linear Model (GENMOO Procedure, distribution = binomal, link function = probit; SAS Institute 1996). Overdispersion problems associated with the binomial distribution models were controlled by estimating the dispersion parameter as Pearson's chi-square (SAS Institute 1996).

In the case of survival in the greenhouse experiment preplanned contrasts between trees differing in either concentration of gallotannins, concentration of proteins, or both were done to test whether these factors were affecting affected larval survivorship. Variation among trees on growth during second instar was also studied. Since growth of larvae was normally distributed, differences between trees were analyzed by fitting a General Linear Model (GLM Procedure). Again pre-planned contrasts between trees differing in either concentration of gallotannins, concentration of proteins, or both were conducted to test for the effects of these factors on larval growth. Power of the design to detect differences between trees was calculated with GPOWER (Buchner et al. 1997), note that the power of pre-planned contrasts is always higher (SAS Institute 1996). Larvae that lose their mark or were weighed after molting to 3rd third instar were excluded from growth analyses.

Results

Ballooning experiment

The experimental procedure was found to be effective since most of larvae placed on both the glass bar and the pine branch moved away in less than one hour. However, only 14 out of 459 neonate larvae did balloon from the stems of mountain birch branches of the 30 experimental birch trees. Although these balloons were not uniformly distributed among trees (Wald's χ^2 = 131.6, df = 28, P << 0.0001) in no case we observed more than 3 larvae ballooning (Fig. 1) suggesting that variation is very low and presumably biologically irrelevant.

Greenhouse experiment

Only two larvae out of the 196 initially placed on plants did not survive to the second in star. Mean (± SD) larvae body mass at the beginning of the second instar was on average (± SD) 0.73 ± 0 12 mg, and differences in the mean body mass of larvae feeding on different trees were not statistically significant (P > 0.5). Power of the design at P = 0.05 was higher than 0.90 from an effect size of 0.31, that represented a difference of 0.037 mg in larval weight.

Eighteen percent of the larvae

died during the second instar. Larvae that survived were significantly heavier at the beginning of the instar (0.75 ± 0.11 mg) than those that died (068 ± 0.13; $F_{1,177}$= 11.5, P=<00009001). Survival! rates varied between trees in such a way that differences were statistically significant for the interaction between proteins and gallotannins levels (Table 2) with survival being higher in trees with low levels of both (96 %) than in those with high levels of both (70 %).

An increment of protein concentration increased mortality (Fig, 2a), particularly when gallotannin levels were low (Table 2). The increment of gallotannins also increased mortality (Fig 2b), although differences were only marginally significant when protein concentration was low (Table 2), and non significant when concentration of proteins was high (Table 2).

As regards growth, the mean increment of body mass during the second instar was 1.79 mg (± 037), and the mean larval mass at the end of the instar was 254mg (± 041). I did not find significant differences between growth of larvae feeding on different trees, and none of the pre-planned contrasts was statistically significant (P > 05).

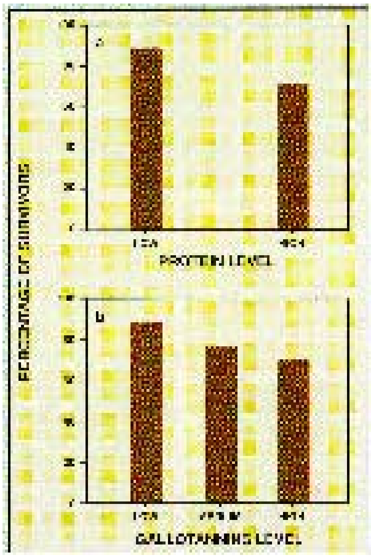

Fig. 2. *Epirrita autumnata* survivorship observed in the greenhouse experiment depending on a) proteins concentration, b) gallotannins concentration.

Discussion

Life-history traits have been suggested to modulate the selective behavior of Lepidopterans (Tammaru and Haukioja 1996). Simple non-selective oviposition behavior is usually associated to polyphagous species with nonfeeding adults and a low flight capability of the females Polyphagy decreases the risks of non-selectivity but still there might be a conflict between mother selection and offspring performance (e.g. Nylin and Janz 1996). Larval dispersal may contribute to alleviate this conflict, and in fact ballooning has been linked to flightless (Roff 1990) and hence to the same group of Lepidopteran species described above. *Epirrita autumnata* has been classified among capital breeders even when adult females can eat and fly because they do not apparently do it (Tammaru and Haukioja 1996, Ruohomäki et al. 2000), ovipositing females do not select between host and non-host species nor between birch trees differing in leaf quality (Tammaru et al. 1995). However, under laboratory conditions larval performance is affected by the individual host-tree in which they feed (e.g., Kause et al. 1999, Lempa et al. 2000) suggesting that individual trees differ in their quality as a host. It rested to know whether larvae were more prone to disperse from trees where their performance was worse and here I checked it by using the same trees than Lempa et al. (2000). Results from the ballooning experiment suggested that neonate larvae have the capability to move from the plant in which they hatch but this behavior is only used when there is no food available (e.g., when they hatch in a non-host plant), but not for selecting host quality at intraspecific level. Similar results have been found by Harrison (1995) in *Orgyia vetusta,* larvae only dispersed from dead bushes but did not moved away from live respond bushes differing in their to the level of defoliation level of alive bushes. Thus, risks associated to this type of uncontrolled dispersal may preclude larvae to escape from any suitable food plant and in natural conditions rates of dispersal from individual plants would be mostly determined by wind and microhabitat location (e.g., Ghent 1999,

Table 2. Results of the Generalized Linear Model fitted to test for differences in survival of second instar E. *autumnata* larvae between trees differing in concentration of either proteins, gallotannins, or both.

Contrast	Compared trees	Wald's X^2	*P*
Between **gallotannin** levels when , concentration of proteins is high	7 *vs.* 9	0.11	0.74
Between **gallotannin** levels when concentration of proteins is low	21,27 *vs.* 4,11	5.36	0.02
Between **protein** concentrations when gallotannins are medium	11 *vs.* 29	4.15	0.042
Between **protein** concentrations when gallotannins are low	7 *vs.* 21,27	9.90	**0.0017**
Low proteins **low** gallotannins vs. **high** proteins **high** gallotannins	21,27 *vs.* 9	12.37	**0.0004**

but see Hunter and Elkinton 1999).

As regards mortality of young larvae, in a greenhouse experiment where natural enemies and abiotic conditions were under control, the biggest difference in survival to the end of second instar was found between trees with low contents of both proteins and hydrolizable tannins (96 % of survivors) and trees with high levels of both proteins and hydrolizable tannins (70 %).

Although the causes of this pattern are uncertain, likely, bounding of proteins was more effective when concentration of both proteins and tannins were in was high concentration (see Zucker 1983 for further discussion), this would decrease larval growth and subsequently the probabilities of dying increased. Interestingly, individuals who died were those recording lightest weight at the beginning of the instar. This last finding is particularly relevant when we try to extrapolate the results to natural conditions. Mortality in the greenhouse was unusually low in first instar compared to natural patterns (personal observation) and causes of death during the second instar were presumably not the same as in the field. However, results suggest that the main effect of a poor food quality food is to weaken individuals feeding on it and this will probably interact with other abiotic factors such as temperature and natural enemies (Virtanen and Neuvonen 1999).

Acknowledgements

I am grateful to the staff of Kevo Subarctic Institute Station and Satakunta Environmental Research Centre for their assistance during the experiments, to Erkki Haukioja for introducing me to the study system, to Seppo Neuvonen and Kai Ruohomäki for discussing with me about ballooning experiments, to Marianna Riipi for her assistance during the greenhouse experiment, and to the organizers of the NSSE workshop for providing me the opportunity to discuss these results. Seppo Neuvonen made useful comments on the paper. The study was founded by the European Commission through TMR-Marie Curie fellowship (ERBFMBICT983034)

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PIRJO WELLING AND KARI LAINE

Regeneration by seed above the timberline

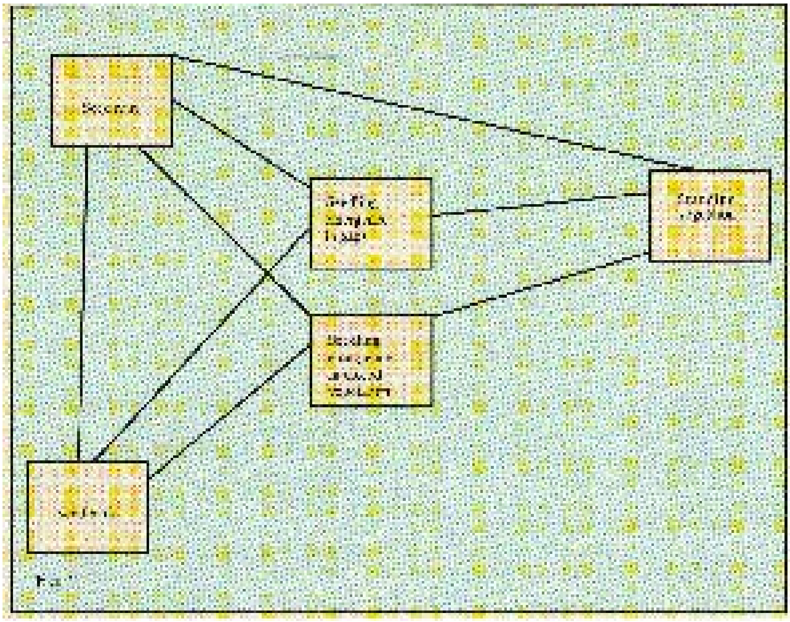
SAMANTEKT
Jafnvel nú er oft gert ráð fyrir að nýliðun með fræjum sé lítil í fjalla- og heimskautagróðri. Samt eru margar kannanir sem mæla gegn þessu. Þéttleiki fræplantna á ofangreindum svæðum er sambærilegur við þéttleika fræplantna á suðlægari svæðum, og reyndar hafa mælst nokkur met á heimsvísu í Norður-Finnlandi og á Ellesmere Island.
Í fjallsheiðum á sér stað virk uppsöfnun fræforða vegna þess að umhverfisskilyrði koma næstum alveg í veg fyrir að plönturnar nái að hefja vöxt. Aftur á móti í valllendi gengur hratt á fræforðann er fræplönturnar vaxa úr moldinni. I báðum gróðurlendunum er fræspírun svipuð í opnum í sverðinum eins og í lokuðum sverði. Nokkrir eiginleikar plantna hafa áhrif á það hvernig nýliðun úr fræi tekst. Í valllendi eiga sér stað breytingar á mikilvægi þátta sem ákvarða vaxtarlag plantna, leiðir þeirra til fjölgunar með kynlausri æxlun eða kynæxlun, lögun fræja vegna dreifingar og fræstærð á lífsferlinum. Gróðursamsetningin breytist því mikið meðan á ferlinu stendur. Þrátt fyrir þessar breytingar eru plöntur sem fjölga sér á kynlausan hátt ríkjandi í gróðrinum.

The significance of regeneration by seed above the timberline
Even today it is often assumed that seed regeneration has little significance in the regeneration of arctic and alpine plant communities and populations (Archibold 1995). Regeneration should proceed mainly by vegetative means in these harsh environments. Seed production often fails, and seedling survival is low (Wager 1938, Billings 1974). However, the first contradictory observations emerged at the same time as those of Wager (1938).

Söyrinki (1938) found in the late 1930's that the total seedling densities are commonly several hundreds, even thousands of seedlings per square meter (m^2) in the Petsamo District, subarctic Finland. Several decades later, Freedman *et al.* (1982) and McGraw and Shaver (1982) also found high total seedling densities in the arctic region: at Ellesmere Island, High Arctic Canada, 13-5916 seedlings / m^2, and in Alaska, 35-3376 seedlings / m^2. Furthermore, the total densities of seed banks are often several hundreds or even thousands of seedlings / m^2 (Freedman *et al.* 1982, Fox 1983, Roach 1983, Chambers 1993, Semenova and Onipchenko 1993, Welling and Laine 2000). Seedling survivorship can be surprisingly high, more than 50% after two growing seasons (Chambers 1995). In Kilpisjärvi, in northern Finland, the species reproducing mainly by seed are important in maintaining the species richness of alpine vegetation (Welling 2000). The total seedling densities found in arctic and alpine areas are comparable with the seedling densities found in more southern areas, and some global maxima have been recorded in northern Finland (Söyrinki 1938) and on the Ellesmere Islands (Freedman et al. 1982). These records reveal that seed and seedling dynamics is worth much attention in arctic and alpine research programs.

Features of seed regeneration in alpine plant communities
There are several phases in the pathway of seed regeneration (Fig. 1). Several factors affect the density, quality and species richness of seed and seedling floras in different regeneration phases, and the relationships between these phases.

The density of seed rain varies widely from year to year in alpine areas (Chambers 1993, Molau and Larsson 2000). The density and



the quality of seeds in the seed rain affects the success of the particular year's seed rain in seedling recruitment. Seeds should also drop on suitable microsites for seed germination and seedling recruitment, which does not necessarily happen (Schupp 1995).

A soil seed bank is the product of a seed rain of many years, even decades. The seeds accumulating in the seed bank have several alternative fates (Simpson et al. 1989). Some of them may germinate, or some may lose their viability because of physiological death or pathogens. Some of them can be eaten by predators or become buried in deep layers of the soil. Rabinowich and Rapp (1980) and Schott and Hamburg (1997) recorded a reduction in the seed number from the seed rain to the seed bank of prairie and old field vegetation. This pattern reflects an effective eradication of the seed bank via seed germination and death. In an alpine undisturbed heath the seed bank (germinated in a green house) and the seed rain are dense. However, environmental conditions almost completely prevent seedling emergence from the seed bank in the field (Welling and Laine a, in prep.). On the other hand, in an alpine meadow, seedling emergence from the seed bank in the field is effective.

Drought and low temperatures limit seed germination, and therefore affect seedling recruitment from the seed bank. On the other hand, needle ice activity and soil drought are important constraints on seedling survival. Disturbed, open patches facilitate seed germination and seedling survival. This is because disturbances decrease competition by destroying vegetation and providing better light, temperature and nutrient conditions for the seedlings (Chambers 1995). Surprisingly, comparable seedling emergence was found in gaps and closed vegetation of an alpine meadow and heath (Welling and Laine a, in prep.). In the meadow, a shift in the dominant seedling flora from gaps to closed vegetation seems to be a reason for the comparable seedling emergence in these patches. In the heath, probably drought prevents seedling emergence in gaps as effectively as the thick moss cover in closed vegetation.

Several plant traits, for instance diaspore morphology, seed size, state of clonality and growth form, have a role in the success of plants during the regeneration pathway. The consequences of seed size - small or large - are apparent in regeneration. Small seeds dominate the seed rain (Chambers 1993, Welling and Laine b, in prep.) and the seed bank (Chambers 1993, Thompson et al. 1998). On the other hand, a large seed is an advantage in colonization, especially that of closed vegetation (Kiviniemi 1999) Appendaged diaspores have an ability to disperse longer distances than non-appendaged diaspores, but appendages may limit burial in the soil (Rabinowich 1981). The diaspores which are not buried are exposed to predation, heat and drought. Thus, appendiges may limit seedling emergence and recruitment.

Many herbs and sedges are known to demand light for seed germination, but grasses are tolerant to shade (Grime et al. 1987, Chambers 1987, Schütz and Rave 1999). Herbs and sedges should therefore demand gaps for seed germination. On the other hand, grasses should germinate in closed vegetation effectively. However, narrow leaves may limit seedling recruitment of grasses in closed vegetation. In clonal plants seedlings are commonly rare (Eriksson 1992). Clonal plants are abundant in standing vegetation, however, because of their large size and effective vegetative spreading.

In all, particular plant traits go

through several filters in the pathway of regeneration. As presented, the particular plant trait may be an advantage in some phases and a disadvantage in another. In an alpine meadow, several changes happen in the relative proportions of growth forms, states of clonality, diaspore morphologies and seed sizes across the regeneration pathway, partly in an expected way (Welling and Laine b. in prep). These changes are the reasons for relatively low floristic similarity between the consecutive regeneration phases in the regeneration pathway. However despite this low similarity, aclonal plants dominate the standing vegetation. This indicates that regeneration by seed is effective in this community.

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JÓN GEIR PÉTURSSON, AÐALSTEINN SIGURGEIRSSON
AND VIGNIR SIGURÐSSON

Forest regeneration in a cold climate:

Alternative methods

SAMANTEKT
Meginmarkmið þessara rannsókna er að afla þekkingar til þess að geta hagnýtt beinar sáningar barrtrjáfræs í nýskógrækt á Íslandi.

Helstu niðurstöður þessa verkefnis eru þær að í kjölfar beinna sáninga barrtrjáfræs spírar fræið ágætlega og sáðplöntur komast á legg. Ekki er sjáanlegur marktækur munur á því milli Suður- og Austurlands. Af þeim trjátegundum sem notaðar voru gaf sáning stafafuru jafn bestan árangur. Á Héraði skilaði þó sáning rússalerkis viðunandi árangri, en vegna þess hve fræverð er hátt um þessar mundir er aðferðin tæpast raunhæfur kostur í lerkiskógrækt. Á sama hátt gaf notkun plastkeilu jafnbestan árangur við sáningar, bæði hvað varðar spírun, lifun og vöxt plantnanna. Þess ber þó að geta að á Héraði voru áhrif keilunnar mun minni en í Mosfelli, sérstaklega á lifun og vöxt plantna. Skýrist það væntanlega af hagstæðu veðurfari svæðisins. Í Mosfelli virðist skjólið af keilunni ráða úrslitum fyrir lífslíkur plantna. Keilan kemur einnig í veg fyrir afrán á fræi, en það getur verið mikið vandamál við beinsáningar hér, bæði í Mosfelli og Höfða.

Athygli vekur hversu vöxtur á sáðplöntunum er lítill fyrstu sumrin. Þær virðast lenda í vaxtarstöðnun *(stagnation)* sem væntanlega skýrist af næringarskorti og hugsanlega skorti á sambýlisörverum, s.s. svepprót. Tilraunir sem hófust haustið 1997 með áburðargjöf benda til þess að hún auki vöxt plantna og sé nauðsynleg við beinar sáningar hérlendis.

Afföll plantna orsakast af svipuðum þáttum og þekkt eru úr gróðursetningarstarfinu, þ.e.a.s. frostlyftingu, frostskemmdum, þurrki og ranabjöllunagi. Skipulag beinna sáninga þarf að taka tillit til allra þessara þátta ef vel á að takast til.

Ávinningur beinna sáninga virðist vera mestur þegar notuð er stafafura. Orsakast það af nokkrum þáttum. Fræ hennar er tiltölulega ódýrt og fyrirsjáanlega verður töluvert framboð af því hér innanlands. Hún er ræktuð í tiltölulega þurru mólendi, en þar er helst hægt að mæla með sáningum og einnig ættu rótarvanskköpun og stofnsveigjur að vera minna vandamál eftir beina sáningu en eftir gróðursetningu.

Þessar tilraunir renna stoðum undir það, að beinar sáningar á barrtrjáfræi í útjörð geti gefið áþekkan árangur og vænta má af hefðbundnum gróðursetningum. Mikill munur er þó á milli einstakra sáningaraðferða og ljóst að ekki dugir að sá fræinu einu og sér. Hjálparaðgerðir eru því nauðsynlegar ef fullnægjandi árangur á að nást.

Introduction

At present, Iceland is Europe's least-forested country, with less than 1,4% of the land area covered by forests or woodlands. Eleven centuries of human habitation, deforestation and overgrazing have resulted in a loss of 95-97% of the original forest cover. Afforestation efforts are currently increasing, and there is interest in developing alternative, inexpensive and efficient afforestation methods.

During the last seven years, experiments have been carried out aimed at investigating some alternative forest regeneration methods in the cool, maritime climate of Iceland. The main emphasis has been on direct seeding of the three conifer species most commonly used in Iceland; Sitka spruce *(Picea sitchensis* (Bong.) Carr), lodgepole pine (*Pinus contorta* Dougl. var. *contorta)* and Siberian larch (*Larix sibirica* Ledeb.)

The main objectives of the research have been; 1) to investigate the possibility of using direct seeding of introduced conifer species, as a low-cost alternative to planting for afforestation in Iceland, 2) to compare different techniques for direct seeding of the different tree species and
3) to compare different locations and different sites.

This short article gives a brief overview of the trials involved and summarises the main conclusions after seven years.

Materials and methods

The experimental sites

The seeding trials have been put out at two locations, Mosfell in S-Iceland and Höfði in E-Iceland.

Both locations are within the areas considered best suited for afforestation in Iceland.

At Mosfell, the terrain is flat and exposed to winds from all directions. The soils on the experimental site are freely drained palagonite loesses. The vegetation is a hummock-heath, dominated by *Rachomitrium* spp., *Empetrum nigrum* and other dwarf shrubs.

At Höfði, the trials were placed out on two different sites, a *Kobresia*-*Empetrum*-heath and moorland dominated by *Betula nana.* The soils here are similar to those at Mosfell, with the *Kobresia*-heath somewhat dryer than the *Betula nana* moor.

Table 1. Some meteorological observations from the nearest local weather stations to the experimental sites, Hæli (Mosfell) and Hallormsstaður (Höfði)

Climatic data*	Hæli (Mosfell)	Hallormsstaður (Höfði)
Mean precipitation, *year* (mm)	1148	757
Mean temperature, summer *Jun.-Sept.* (°C)	9,1	8,9
Mean max. temperature *Jun.-Sept.* (°C)	12,7	12,7
Mean number of days exc. + 15°C	29	43
Mean number of days exc. +6°C	131	121

*Received from the Icelandic Meteorological Institute.

Table 2. Description of the regeneration methods used in the trials on the scarified seed spots in Mosfell 1993 and Höfði 1996

Method	Description*
Control	Sown directly
Covered with gravel	Seeds covered with approx. 27 cm^3 of gravel, diameter from 0,3 - 0,8 cm
Covered with pumice	Seeds covered with approx. 27 cm^3 of pumice having diameter from 0,1 - 1 cm
Plastic cone	"Cercon" cone, 80 mm high, bottom diam. 59 mm and tap diam. 17 mm
Pyramidal indentation	Tool consisting of 10 pyramids, turned upside down, with base 4x4 cm and height 2cm, put together in two rows of 5 in.
Spring planting	Planting containerised forest tree seedlings, using planting dibble.
Autumn planting	Planting containerised forest tree seedlings, using planting dibble.

Autumn planting Planting containerised forest tree seedlings using planting dibble.

Table 3. Description of the seeding methods used in the trials on TTS disc-scarified ground in Mosfell and Höfði 1997

Method	Description
Control	Sown directly
Plastic cone	"Cercon" cone 80 mm high, bottom diam. 59 mm and top diam. 17 mm
Bio-pack*	Fertiliser-kit,10 gr. Biodegradable bag including coated, slow release fertiliser (N16, P6, K8, S2.7, Fe0.7, Mn 0.15, Zn 0.54)
Cluster-pack*	Direct seeding-kit. Biodegradable bag including seeds, Sphagnum moss, water storing polymers, bio-stimulants and mycorrhizae inoculum.

* Products of Reforestation Technologies International Inc.

Three different trials

On each site, various forest regeneration methods have been compared. In all trials, the directions concerning seed stratification, exact counting and sowing performance given in Jón Geir Pétursson (1995) have been followed. The most commonly used forest tree seedlings and planting method were used for comparison.

Trials from 1993 at Mosfell

These trials were put out using sitka spruce, lodgepole pine and Siberian larch, comparing various regeneration methods. The main research questions in these trials were:

- Does imported coniferous seed germinate in the cold Icelandic climate?
- Which species/methods are the most useful?
- Do the seedlings establish and grow properly?
- Are some of the direct seeding methods comparable to planting forest seedlings?

Descriptions of these trials and detailed results have been presented by the authors on various occasions (Jón Geir Pétursson, 1995; Jón Geir Pétursson and Aðalsteinn Sigurgeirsson, 1997).

Trials from 1996 at Höfði

Here, similar trials as in Mosfell 1993 were put out in a location in E-Iceland, although Sitka spruce was not used. The aim of the 1996 trials, additional to the ones in the 1993 trials, was mainly to compare different microsites and locations in Iceland. The trials were placed out in June, following the same procedures as in the 1993 trials.

Trials from 1997 at Höfði and Mosfell

These trials were placed out on both sites, using lodgepole pine and Siberian larch in Höfði and lodgepole pine, Sitka spruce, Siberian larch and native downy birch *(Betula pubescens*) in Mosfell. The main research questions here were:

- Is it possible to improve the results of direct seeding by using „seeding kits", including fertilisers (Table 3)?
- Can satisfactory results be obtained from direct seeding on sites prepared by the most commonly used mechanised scarification equipment?

The trials have been measured regularly. Statistical analyses (ANOVA) were performed using SPSS. All data were *arcsine* transformed to meet assumptions of normality and variance homogeneity.

Results

All the three trials showed similar tendencies. After the first summer in the Mosfell 1993 trial, 111 % of the sown seeds had germinated. Germination continued during the second summer, resulting in a total germination of 30% for all methods and species. Seedling mortality was high during the first winter, except under cones, where more than 80% of the seedlings survived. Differences between tree species in the number of seeding/planting spots with one or more living seedling were significant at the beginning of fourth growing season with lodgepole pine giving significantly better

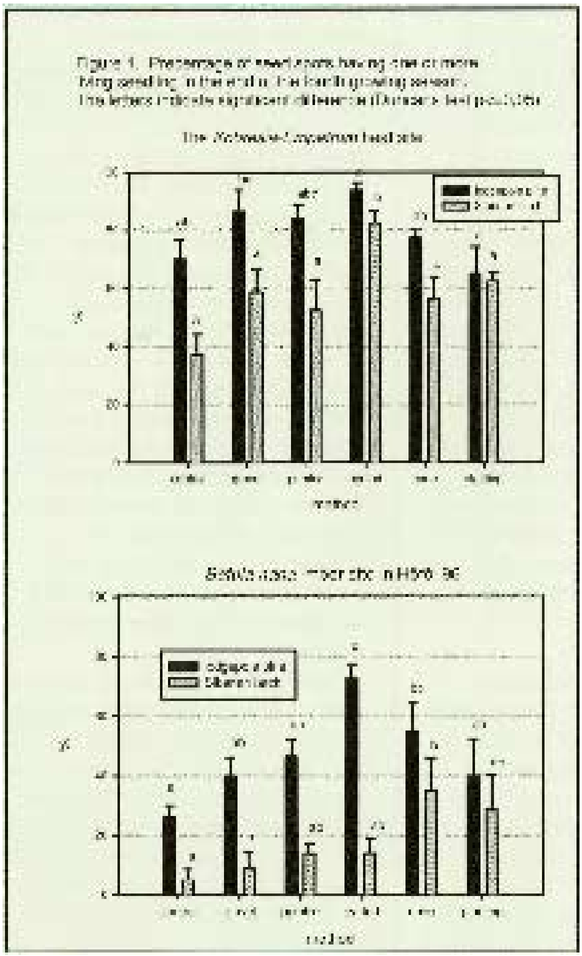
Table 4. ANOVA on the percentage of spots having at least one living seedling at the end of the fourth growing season in the trials from Höfði 1996, inventoried in autumn 1999.

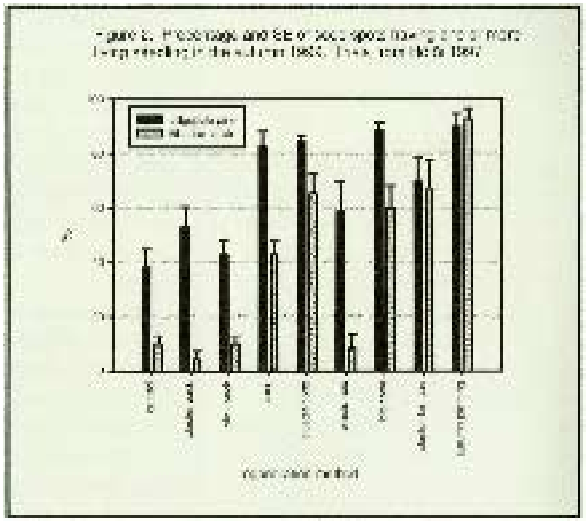
Source of variation		
	df	*P*
species	1	0,000*
methods	*5*	0,000*
microsites	1	0,000*
block	3	0,019*
block (Microsite)	3	0,066
species=microsite	1	0,949
microsite*method	*5*	0,018*
Species*method	*5*	0,042*

** Indicates significant difference at α=0,05

results than Siberian larch and Sitka spruce (see more detailed in Jón Geir Pétursson and Aðalsteinn Sigurgeirsson, 1997).

In the trials at Höfði from 1996, the total germination was higher for lodgepole pine than Siberian larch. Lodgepole pine seed had similar germination results under the plastic cones (60%) and in the pyramidal indentions (50%). Germination was significantly lower for Siberian larch, but the same methods were the most beneficial or 40% in the cones and 35% in the pyramidal indentions.





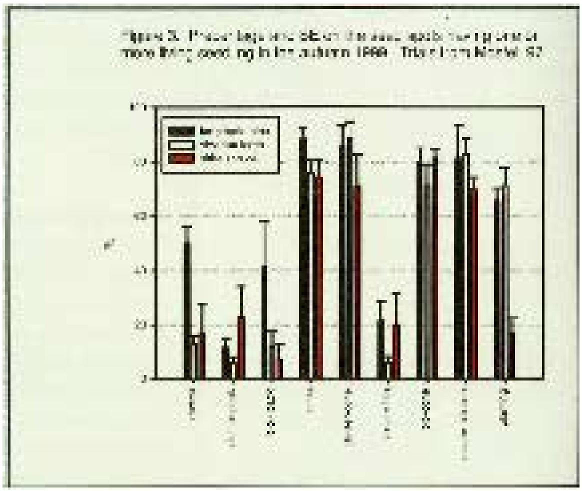


Fig. 1. Four year old Siberian larch seedlings emerged from direct seeding using pyramidal indentations as a micro site preparation.

Fig. 2. Stagnated growth („check") of seedlings was frequently observed in the trials, like these -4-year-old lodgepole pine seedlings seen here in Höfði. There are indications, however, that this can be alleviated through the use of slow-release fertilisers.

There was a significant difference between the microsites, both concerning germination and seedling establishment, with the *Kobresia*-heath site giving much better results. There were problems scarifying the *Betula nana* moorland site properly, giving much poorer seed spots, and seed predation, probably by mice, was a big problem there.

Lodgepole pine gave significantly better seedling establishment than the Siberian larch. When sown in the *Kobresia*-heath using plastic cones, 78% of the lodgepole pine spots had one or more living seedling after four growing seasons, compared to only 58% of the Siberian larch spots.

Comparing the results of seedling establishment for planting and direct seeding after four growing seasons, direct seeding using pyramidal indentions provides a significantly higher number of spots with at least one living seedling than planting.

The seedlings, both from direct seeding and planting, had strong evidenced of stagnated growth, having yellowish colour and short needles. The lodgepole pine seedlings were similar in size from all seeding methods, but for Siberian larch, seedlings in the plastic cones and pyramidal indentations were significantly taller than those in control spots.

The regeneration trials from 1997 in Mosfell and Höfði gave generally similar results as those from 1993 and 1996. Direct seeding after tractor-driven TTS scarification was possible without any significant problems. Using the plastic cones gave far better results than the control and gave competive results to planting. There were indications that the seedlings emerging under the cones with the fertiliser packs were larger and better established.

Discussion and conclusions

It can be argued that direct seeding of coniferous seeds can give similar results as obtained by planting forest tree seedlings in the cold Icelandic climate (Jón Geir Pétursson and Aðalsteinn Sigurgeirsson, 1997). However, there were enormous differences between methods and it is evident that unless some supporting method is used, the results will be very poor. The best overall results were obtained when using plastic cones, regardless of the tree species in question. Temperature and moisture both increase under the cones, which is beneficial both for the seed germination and seedling establishment. They also provide shelter for the seedling during the first two years and prevent seed predation. Using them, the amount of seed sown can be decreased by about a factor of 4 compared to the other seeding methods

Seed predetation must be considered when using direct seeding in Iceland, as in other countries. The seed predators are likely both mice and birds. The relatively large Siberian larch seeds are especially vulnerable, but also to some degree, smaller seeds like those of lodgepole pine.

There was a substantial difference in seedling mortality of the various tree species between the two locations. Direct seeding of lodgepole pine, using the plastic cones, provided equally good results on both sites or about 80% of the seed spots with at least one living seedling at the end of the fourth growing season. However, the same method for Siberian larch yielded a satisfactory 80% of the spots with at least one living seedling at Höfði, but only 7,5% at Mosfell. Very high mortality was found for the Sitka spruce seedlings, giving very poor results.

The seedlings show very poor growth in all the trials. Seedling stagnation is known from other countries at northern latitudes and is often traced to the leaching of essential nutrients in the soil. Another reason might been undeveloped or non-existing mycorriza, vital for the establishment and growth of the seedling. The trials put out in autumn 1997 were aimed at finding solutions on this problem, but at the time of the inventories, no significant difference was found between the fertilised seedlings and the others. There were however some indications of positive effects from the fertilizers. This effect might become evident after a longer time.

After seven years of studies, the following inferences can be made:

- The germination rate of Sitka spruce, Siberian larch, and lodgepole pine seed in Iceland is comparable to that which is common in countries at similar latitudes.
- Seed predation, by wood mice and/or birds can be a serious problem.
- Direct seeding of lodgepole pine gave by far the best results of the species tried, both concerning germination and seedling establishment. In East Iceland, direct seeding of Siberian larch can be considered a viable alternative to planting.
- Of the seeding methods tried, the use of a plastic cone was the most beneficial for all the tree species and fully comparable to planting as regards establishment success. Furthermore, problems owing to seed predation can be avoided through the use of the seeding cone.
- Stagnated growth („check") of seedlings was common in all the trials. There are indications, however, that this can be alleviated through the use of slow-release fertilisers.
- Using mechanical site preparation, direct seeding of lodgepole pine can be an economically feasible alternative to planting, especially given the well-known stability problems of planted lodgepole pine.

Acknowledgements
The work was supported by the National Science Council of Iceland (Rannís), the Foundation for Agricultural Production in Iceland, the Icelandic Forestry Association and the Iceland Forest Service and we are grateful for their support. We also wish to thank the staff at Heradsskogar; Sudurlandsskogar, Iceland Forest Service and Icelandic Forestry Association for their help in the fieldwork.

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BRYNJAR SKÚLASON, AÐALSTEINN SIGURGEIRSSON, BJARNI E. GUÐLEIFSSON AND ØYVIND MELAND EDVARDSEN

Frost tolerance among provenances and families from the *Picea* complex in Alaska

SAMANTEKT
Af þeim trjátegundum sem ræktaðar eru á Íslandi eru mestar vonir bundnar við sitkagreni sem timburtré á Suður- og Vesturlandi. Reynslan er þó sú að sitkagreni verður á ungaaldri fyrir frostskemmdum bæði vor og haust. Til að kanna breytileikann á frostþoli milli grenitegunda, milli kvæma og milli afkvæmahópa innan kvæma voru frostþolspróf framkvæmd á samtals 8000 plöntum vor og haust. Hvítgreni- og sitkabastarðskvæmi reyndust viðkvæmari fyrir vorfrostum en sitkagrenikvæmin, en sitkagrenið aftur viðkvæmara fyrir haustfrostum. Mikill munur var á milli afkvæmahópa innan kvæma, sem bendir til þess að hægt sé að finna efnivið sem er sæmilega frostþolinn bæði vor og haust. Samræmi var milli niðurstaðna frostþolsprófanna og skemmda sem urðu í gróðrarstöð haustið áður. Líklegt er að hægt sé að nota frostþolspróf við skamval á efniviði til notkunar í skógrækt.

Introduction
Sitka spruce *(Picea sitchensis* (Bong.) Carr) is the most promising tree species for production forestry in the cool, oceanic regions of southern and western Iceland. Experience suggests, however, that the species is susceptible to frost damage during late spring and early autumn. Genetic variation in growth rhythm and frost hardiness in spring and autumn among those provenances of Sitka spruce that can be successfully grown under Icelandic conditions was examined with the aim of reducing frost damage.

Freeze testing under controlled conditions was carried out on a total of 8000 Sitka spruce and Lutz spruce *(Picea x lutzii)* seedlings, from among 10 families from each of 20 provenances. Differences in frost tolerance during spring and autumn were significant among provenances and among families within provenances. Provenances of white spruce *(Picea glauca* ((Moench) Voss) and Lutz spruce were more susceptible to damage from spring frosts than those of Sitka spruce. The converse was however true for autumn frost damage, where damage was greatest in Sitka spruce. Correlations between frost tolerance and latitude, longitude and elevation at origin, as well as seedling height were not significant. There was however a strong and significant relationship between damage observed among provenances and families in the nursery one year earlier, attributed to autumn frosts, and damages observed after controlled freezing conditions in the following autumn. These results suggest the opportunity for using freeze testing for early selection for frost hardiness in the nursery and in the field.

Frost damage to seedlings in Iceland
Fall frost damage to Sitka spruce seedlings is a considerable problem in Iceland, occurring almost every year in some regions, both in nurseries and during the first few years after outplanting. Spring frost damage is less common but can be more severe when it happens.

The main goals of this research were:

- To test the variability in spring and fall frost hardiness among half-sib. families within provenances.
- To test the variability in spring and fall frost hardiness among provenances.
- To test the effect of introgression between Sitka and white spruce on dehardening in spring and inwintering in fall.
- To test the possibility of using frost hardiness testing in early selection of hardy provenances and families of Sitka spruce.

Material and methods
A large spruce seed collection took place in Alaska in 1987-1988. This material has been planted in several places in Norway, Sweden, Finland and Iceland. A large proportion of this material

Table 1. Species, provenances and families in the freezing test. SS=Sitka spruce, LS=Lutz spruce, WS=White spruce ES=Engelmann spruce, BS=Black spruce.

Nr.	Provenance	Species	Species [illegible]	Lat. (°N)	Long. (°W)	Alt. (m)	Families
1	Chiniak	SS	SS	57°[illegible]	152°[illegible]	0-50	6
2	Duck Mountain	SS	SS	58°12	152°31	50-300	7
3	Inishkin Bay	SS/LS	SS/LS	59°21	153°25	0-100	9
4	Chinitna Bay	SS	SS/LS	59°50	153°02-06	5-20	9
5	Port Chatham	SS	SS	59°11	151°45	30	6
6	Homer	SS	SS	59°[illegible]	151°[illegible]	[illegible]	[illegible]
7	Ninilchik	LS/WS	LS/WS	[illegible]	[illegible]	[illegible]	[illegible]
8	Kenai City	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	6
9	Resurrection River	SS	SS	[illegible]	[illegible]	[illegible]	[illegible]
10	Seward Road	SS	SS	[illegible]	[illegible]	[illegible]	[illegible]
11	Kenai Lake	[illegible]	WS	[illegible]	[illegible]	[illegible]	[illegible]
12	Cooper Lake	SS	WS	[illegible]	[illegible]	[illegible]	[illegible]
13	Moose Pass	SS	WS	[illegible]	[illegible]	[illegible]	7
15	Hope Road	LS					[illegible]
17	Portage to Girdwood	SS	SS	60°47 [illegible]	[illegible]	[illegible]	5
18	Girdwood	SS	SS	61°	149°[illegible]		5
19	Valdez	SS	SS	61°[illegible]	146°[illegible]	[illegible]	[illegible]
20	Cordova	SS	SS	[illegible]	[illegible]		[illegible]
21	Icy Bay	SS	SS	[illegible]	141°[illegible]	5	3
26	Haines Highway	SS		59°30	136°30	230	5
28	Dyea, Skagway	SS		59°27	135°19	5	
29	Yakutat	SS		59°31	139°40	[illegible]	
30	Cordova	SS		[illegible]	[illegible]	5	
31	Tsiiklik	SS		[illegible]	146°40		
42	[illegible]	SS		Selected families of various origin			
43	Sitka	SS		[illegible]	135°[illegible]		
44	[illegible]	SS		[illegible]			
45	[illegible]	SS		[illegible]			
46	[illegible]	SS		[illegible]			
46	Queen Charlotte	SS		[illegible]	[illegible]	[illegible]	
47	Porcher Island	SS		53°55	130°27	427	
48	Rennell Sound	SS		53°20	132°18	[illegible]	
57	Rio Grande, Colorado	ES		38°	[illegible]		
58	Bluejoint Mtn.	ES		51°	[illegible]		
60	Soldotna	BS		60°30	151°07	[illegible]	

was freeze tested in the spring and fall of 1996 (Table 1).

Shoots were cut from 2-year old potted seedlings and subjected to freezing at two times during spring and two times during fall in 1996. On each date, two minimum temperatures were used, -12 and -18°C, with the temperature decreasing by 2° per hour to these levels. The shoots were then placed on a rooting bench in a warm and humid greenhouse for 14 days. The shoots were then dissected longitudinally and damage to tissues and buds assessed (Figs. 1 and 2).

Results

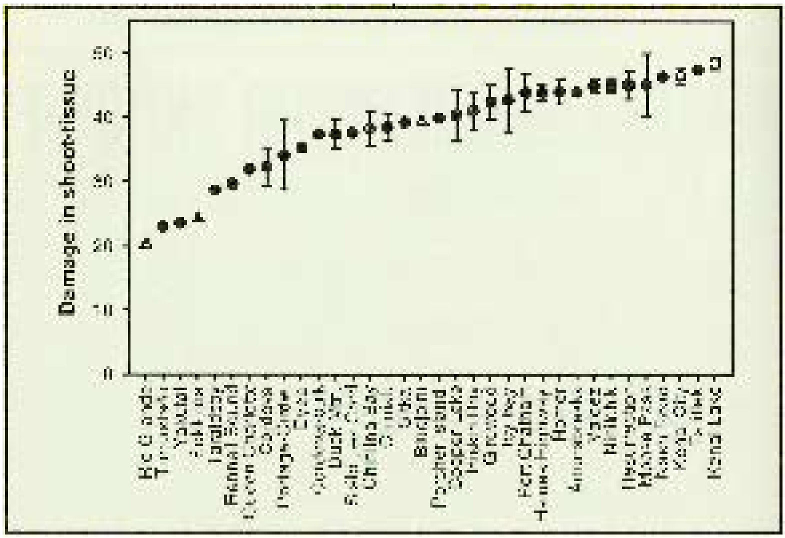
Provenances of white spruce and Lutz spruce were more sensitive to spring frost damage than Sitka spruce provenances but the reverse was true for fall frost damage. The provenance differences were significant, being more pronounced in fall. The proportion of introgressed white spruce genes seems to be the most important determining factor (Figs. 3 and 4).

Significant differences were found in frost hardiness between half-sib. families within most provenances with the greatest differences being within Lutz spruce provenances. The results indicate that it is possible to select families that show good frost tolerance both spring and fall.

Early selection and improvement for frost tolerance

Based on these results, it can be concluded that emphasis should be on selection of 1) species and 2) families that show the desired frost tolerance characteristics. Families should be selected from within provenances that show

Figure 3. Frost damage in shoot tissue. Freezing 18. April at -18°C. Mark 50 indicates brown or black decomposed tissue in the whole shoot (5 cm x 10). The error bars indicates standard deviation. Legend: Sitka spruce ●, white spruce O, lütz spruce l, black spruce s and engelmannspruce.



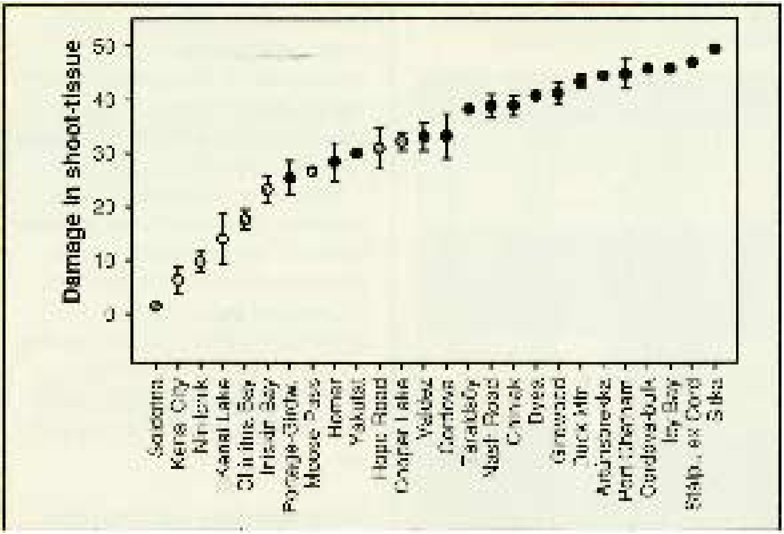


Figure 4. Frost damage in shoot tissue. Freezing 23. September at -18°C. Mark 50 indicates brown or black decomposed tissue in the whole shoot (5 cm x 10). The error bars indicates standard deviation. Legend: Sitka spruce ●. white spruce O, lütz spruce I and black sprucel.

wide genetic variability. Good correlation was found between fall frost tolerance as tested here and incidences of frost damage to nursery stock during the first fall frosts. Selection based on frost hardiness testing should reduce losses in the nursery and during the first years after planting (Fig.5).

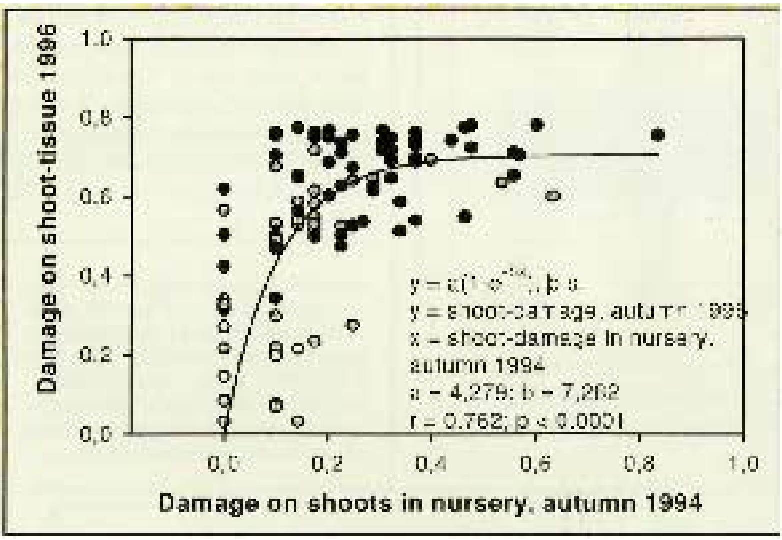


Figure 5. Relationship between observed frost damage in nursery autumn 1994 and tissue frost damages in the freezing test 23. September 1996 at -18°C. Regression analysis of arcsin transformed variables. Legend: Sitka spruce ●, white spruce O and lütz spruce I. Each plot represents a family group.

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STEFANIE LINSER

The Importance of a Theoretical Background of Indicators for the Assessment of Sustainable Forestry

SAMANTEKT
Dagskrá 21, niðurstaða Ríó-ráðstefnunnar um sjálfbæra þróun, gerir ráð fyrir að til verði vísar sem hægt sé að nota til að meta framfarir í sjálfbærri þróun. Grein þessi lýsir fræðilegu baklandi slíkra vísa, kostum þeirra og göllum.

Introduction
Western world understanding of management and value of forests, and its importance in land use planning have changed considerably during the last decades, especially since the first Ministerial Conference on the Protection of Forests in Europe in Strasbourg in 1990, followed by the United Nations Conference on Environment and Development (UNCED) in Rio in 1992, the second Ministerial Conference in Helsinki and the third one in Lisbon in 1998. Questions concerning the work with indicators for the assessment of sustainable forest management have been on the agenda during all these conferences.

Definitions of criteria and indicators
In accordance with the Helsinki-Process (Third Ministerial Conference on the Protection of Forests in Europe 1998), criteria characterize or define the essential elements or set of conditions or processes by which sustainable forest management may be assessed. The direction of change within each criterion is shown by periodically measured indicators.

In the social-scientific discussion and also within the development of environmental indicators, there is a broad consensus about the definition of indicators, which can be named as a deductive approach, because it is derived from theoretical considerations (Fues 1998: 21). The common sense of these concepts is reflected in the following definition of Nohlen (1991: 324)

> *"An indicator is a variable, which mediates or shows quantitative or qualitative information about complex circumstances or problem areas. The indicator informs about observable and measurable dues for certain circumstances or theoretical constructions which are considered to be unobservable"*

Into this social-scientific approach you can also insert the definitions of indicators used within the forest certification process (Schneider 1995):

- An indicator is a quantitative measure of an effect, which can not specify itself whether the modification is good or bad. And an indicator is a quantitative measure of time-related changes to indicate how well each criterion meets the goals set. (Helsinki-Process).
- An indicator is a measurement of an aspect of the criterion - a quantitative or qualitative variable which can be measured or described and which when observed periodically demonstrates trends (Montreal-Process).

Functions of indicators
Indicators are needed because people are concerned about the environment. People need to be informed about the state of the environment and how and why it is changing, so that they can easily understand and monitor government policies. Indicators can provide a means of linking environmental impacts to socio-economic activity, and may in some

cases provide early warning of potential environmental problems arising from human activity. Indicators can help to demonstrate the efforts that policymakers have made towards sustainable development, and to signal if the objectives have been achieved and they can help to clarify the confusion caused by the mass of available statistical data (ICLEI 1999; Rennings 1994: 6; UK Department of the Environment 1996: 2).

The following six main functions of indicators can be derived (Krupp and Zapf 1988: 122; Nohlen and Nuscheler 1993: 80; SRU 1994: 86).

The construction and use of indicators does not necessarily presume the determination of defined targets for action. In scientific research the data may, for example, just be used for analytical purposes. However, within the public and political debate about sustainable development, such target setting is required.

Characteristics of indicators

Having determined the fundamental purposes and functions of indicators, the most important characteristics of indicators will now be described. There are seven aspects that are of special importance for indicators to function as is desired.

Criteria of choice

Before the question of *how* something is to be measured is asked, it is necessary to clarify *what* is to be measured. Therefore, an analytical model is needed to derive the connection between relevant circumstances and the indicator. Indicators should be theoretically based and empirically significant.

The data forming the indicator should be of highest quality that funding will allow and to be relevant it must be updated regularly. Survey methods must meet minimum scientific requirements. Problems of data availability and adequate data quality are: general lack of databases, insufficient management of data processing and lack of trustworthiness (fear of manipulation by certain interest groups) (MacGillivray and Zadeck 1995: 10). In spite of very good databases in several countries, there are wide gaps concerning central problems even in highly industrialized countries, for example, in the case of controversial topics such as social inequality (Willcocks 1995: 82).

An important criteria for the acceptance of an indicator is its relevance to the problem, its scientific viability and its relevance for political decision making and control. The data should be easy to interpret and reveal trends in time in order to be able to point out successes or failures of human influences. The relevance for policy increases if there are already politically decided threshold degrees (Fues 1998: 34). However, indicators are not only chosen because they are the

Main functions of Indicators	
Reporting	[illegible]
Communication	[illegible]
Forecasting	[illegible]
Focusing	[illegible]
Political Control	[illegible]
Check of Effectiveness	[illegible]

Characteristics of indicators	
Descriptive or Systemic Indicators	[illegible]
Static or Dynamic Indicators	[illegible]
Objective Reference Level	[illegible]
Causal Reference Level	[illegible]
Dimension	[illegible]
Measurability	[illegible]
International Comparability	[illegible]

most suitable for making objective predictions about the status of a system but also because there is a consensus that they are able to do so. Indicators are thus dependent on the agreement of those who set up and use them (ICLEI 1999).

Communication is very important for the users of indicators. The understandability of indicators is very important if an indicator-system is to be accepted by target groups, mainly in the public and political arenas. They are unable to understand the relevant information if it is not aggregated or reduced in complexity.

One important goal for the construction and use of indicators is their international comparability. For this purpose it is essential to ratify and observe internationally accepted standards. It is still difficult to compare even simple indicators like "forest area" because the definitions and thus the methods for measuring are different.

Relevance for policy, communication and international comparability appear to contradict analytical foundation, because there is a danger that the scientific validity of the indicators is decreased when using indicators for political purposes. Precise, scientifically based indicators are frequently less understandable for political decision makers and the broader public and they are therefore seldom attended to outside scientific circles (MacGillivray and Zadek 1995: 11). On the other hand, indicators that are attractive to the public very often are not well based scientifically. Therefore precision and understandability must be balanced in an optimal way to obtain a "warm indicator" that is as correct as possible and comprehensible to the non-scientific community.

Requirements for indicators of sustainable development	
Normativity	[illegible]
Long-Range	[illegible]
Scope	[illegible]

Basics and requirements
The international debate about sustainability is based on the following definition by Brundtland (World Commission on Environment and Development 1987):

> *"Sustainable development is development that meets the needs of the present without compromising the ability of future generations to meet their own needs."*

The Brundtland-definition points out that intra- and intergenerational justice of distribution are the main components of sustainable development. However, no definite model for the general context between natural and human systems can be based on it. AGENDA 21, the product of the United Nations Conference on Environment and Development in Rio 1992 and the results of the follow-up conferences make it clear that sustainability can be described by three dimensions. They are 1) ecological, 2) economic and 3) social aspects, which have to be observed over time and on different spatial levels.

Indicators of sustainable development are according to chapter 40.4 of Agenda 21 "*indicators which provide a solid basis for decision-making at all levels and contribute to a self-regulating sustainability of integrated environment and development systems".* Meadows (s.t) points out that *"an environmental indicator becomes a sustainability indicator with the addition of time, limit or target".*

The following requirements of indicators of sustainable development are the results of the definition of sustainable development and its 3 dimensions.

Problems and limits of indicators
It is important to note that with the selection of indicators, value judgements have to be made both with regard to what is important and what targets to set (BUND and Misereor 1996: 38). Ideally, indicators should allow conclusions about the cause of change. Strictly suitable indicators are therefore only driving force- or pressure indicators - e.g. greenhouse gas emissions. Indicators describing the status of an environmental medium do not usually allow cause-specific, quantitative prognoses, therefore they can only be used as reference values.

A literature search resulted in the following examples of the suitability of indicators:

- Indicators can help to focus public attention, to shape consciousness, and support communication about key issues, priorities and action strategies (Department of the Environment 1996: 2).
- Indicators help to quantify selected criteria (the problem),

to weigh different options on how to react, and to evaluate the urgency of the requirement for action (Fues 1998: 41, BUND and Misereor 1996: 38).

- Indicators offer a common conceptual framework, which facilitates decision making and consensus finding to the persons taking part in the process (Fues 1998: 42).
- Indicators are absolutely necessary in order to find out whether policy is working and to measure progress (Gouzée et al. 1995: 24).

A second literature search shows limitations of indicators:

- Indicators are used abusively if they are regarded as independent values and if the basic relationship to the regarded circumstances remains unconsidered (Fues 1998: 41).
- "While indicators certainly help to focus on the key issues and highlight some significant trends, they do not by any means give the whole story. They are by their nature simplifications. They also relate only to areas which can be readily quantified and aggregated in a meaningful way to give national statistics." (Dept of Environment 1996: 2).
- "The power implicit in the indicators used for decision making will lead to the selection of unsuitable indicators or their misapplication." (WWF and NEF 1994b: 2).

A survey among the members of the German and the Finnish commissions of sustainable development showed that the majority of the interviewed experts expressed the opinion that indicators are suitable to illustrate long-term development or the dimension of a problem to decision makers as well as to the public. Indicators allow national and global comparability and support international reporting. Indicators are suitable to make decision-making visible, to monitor progress of policy implementation and to point out calls for action. Further on it was mentioned that indicators can serve the process of target-setting. About one third of the interviewed experts expressed the opinion, that indicators are not objective mirrors of reality and that they cannot reflect values nor clarify qualitative phenomena or changes.

Conclusions

Since the Rio Conference, there has been a big effort in developing criteria and indicators for the assessment of sustainable development (Essmann and Linser 1997; SRU 1998). Just a few of those indicator systems are actually in use. Some are too comprehensive, have no underlying database, are superficial or highly aggregated and therefore unintelligible. Indicators of sustainable development that are based on a theoretical background (Linser, 1999) and an extensive statistical database can provide solid bases for decision-making at all levels and contribute to sustainable development.

Most of the already developed indicator systems focus on the measurement and implementation of ecological targets and thus only represent one aspect of sustainable development. Azar et al. (1996), BUND and Misereor (1996) and Walz (1997) criticize the strong emphasis on indicators of environmental status, while the interactions of society and ecological systems are insufficiently considered. Therefore, it is especially important, that criteria and indicators are developed for all three dimensions of sustainability. This requires a collective interaction of the representatives of the social, ecological and economic fields.

The forest sector has always been a leader concerning sustainability, due to the fact that the origin of this concept goes back to forest management at the beginning of the 18th century. In 1992, immediately after Rio, the development of criteria and indicators for sustainable forest management started enthusiastically, for example, within the Helsinki process (Schneider, 1995, p. 184), the Montreal process (Kronauer, 1996, p. 1063) and the Tarapoto process (Schneider, 1997). Mistakes and difficulties occurred, but the will to improve can be seen everywhere. During revision of existing indicator systems, all three dimensions of sustainability have to be given the same weight. Furthermore, concepts have to be elaborated in a participatory approach. With regard to this background, a new, common definition of *sustainable forest management* was laid down in Resolution H1 at the Third Ministerial Conference on the Protection of Forests in Europe in Lisbon, 1998: *"sustainable forest management is the stewardship and use of forests and forest lands in a way, and at a rate, that maintains their biodiversity, productivity, regeneration capacity, vitality and their potential to fulfil, now and in the future, relevant ecological, economic and social functions, at local, national, and global levels, and that does not cause damage to other ecosystems" .*

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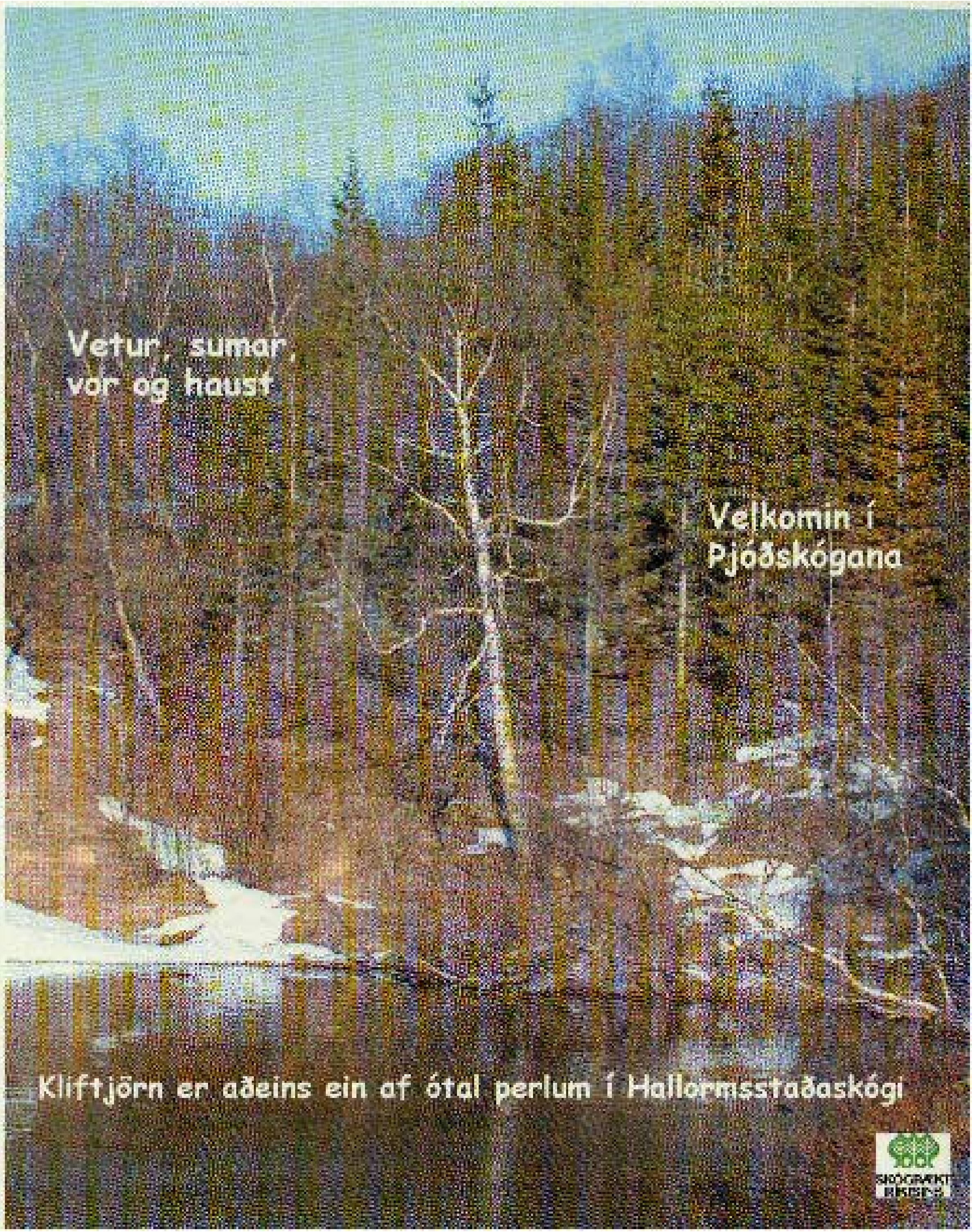
Vetur, sumar, vor og haust
Velkomin í Þjóðskógana
Kliftjörn er aðeins ein af ótal perlum í Hallormsstaðaskógi

STÅLE STØRDAL, SVEIN ERIK HAGEN
AND MORTEN ØRBECK

Regional Structure and Future Prospects of the Forest Industries in Norway

SAMANTEKT
Þróun skógariðnaðarins sem þáttur í atvinnulífinu í Noregi frá 1962- 1997 var könnuð þar sem óttast var að hann væri að dragast saman og flytjast á færri hendur með tilheyrandi byggðaröskun Í för með sér. Framleiðsla tengd skógrækt og úrvinnslu skógarafurða sem hlutfall af þjóðarframleiðslu hefur dregist saman á s.l. 40 árum og er nú vel innan við 2% af heildinni. Hægt er að skoða mikilvægi skógariðnaðar fyrir einstök svæði samanborið við heildina og þá kemur í ljós að hann hefur enn verulega þýðingu á allmörgum stöðum. Þá kom í ljós að miklar tilfærslur voru á atvinnu í skógariðnaði milli 1990 og 1995 og græddu sum svæði á því en önnur töpuðu. Tilhneigingin frá 1980 til 1995 var sú að vinna við framleiðslu viðarafurða fluttist frekar frá þéttbýli til dreifbýlli svæða en að lítil sem engin breyting var á staðsetningu pappírsvinnslu. Helstu niðurstöður eru að 1) skógariðnaður er bundnari við dreifbýlið en flest annað, 2) tilfærsla á atvinnutækifærum hefur átt sér stað en ekki færsla á færri hendur, 3) þessi tilfærsla er þó ekki endilega tengd nálægð við skógarauðlindina (getur tengst þekkingarauðlind) og 4) best gengur þar sem saman fara skógarauðlindin, þekking og framsækinn iðnaður sem er fljótur að aðlagast breyttum aðstæðum og breytilegum mörkuðum.

Introduction
In recent years, reduced harvesting, reduced investment in forestry and restructuring of the industry have led to increasingly larger areas being no longer open to commercial forestry in Norway. One result of this is concentration - not only of the wood processing industries but also of forestry itself. This trend may have consequences for income, employment and also, in the longer term, settlement in many rural regions where forest industries (forestry, manufacture of wood products and pulp and paper) have traditionally held a strong position. This is a worrying development in terms of both forest policy and regional development policy, since much emphasis has been put on the forest sector in the development of districts in Norway. The latest White Paper on forestry in Norway states for example that:
"Forestry is firmly based in the rural areas, and together with agriculture, forestry must continue to be a sustaining force in the commercial development of a great many municipalities in Norway."

In this article, we analyse the development of the forest industries in Norway from a regional point of view. We first present national statistics for gross product and employment in forest industries in the period 1962-97. We also look at the regions that have the largest forest-related employment, and how this has changed in the period 1980-1995. In conclusion we discuss how the forest-based industries could develop their regional role.

Structure and development of forest industries in Norway
National Importance
The total gross product for the forest industries in 1997 was NOK 12.3 billion. This corresponds to 1.6 % of the GDP for mainland Norway (offshore oil and gas activities excluded). The employment in the forest industries in 1997 was 32.800 normal man-years, corresponding to 1.8% of employment in mainland Norway.

The forest industries' share of both the mainland-GDP and employment fell steadily in the period 1962 to 1999. The share of total employment was reduced from 5.1% to 1.6 per cent, as shown in Figure 1.

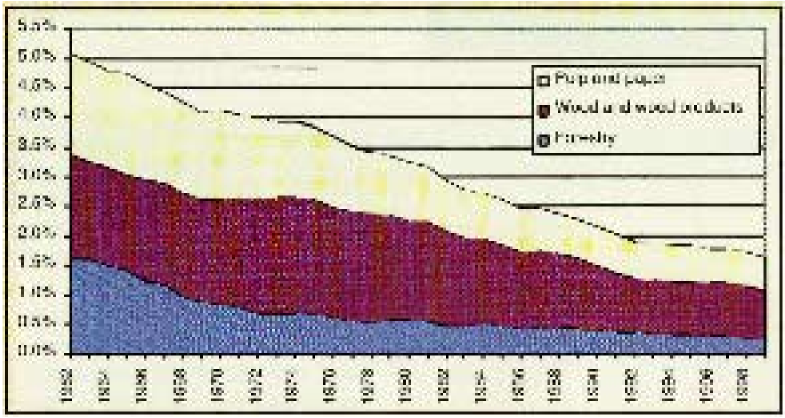

Figure 1. Forest industries' share of mainland Norway's man-year employment 1962-99.

Regional Importance

In our assessment of the forest industries' importance as an employment factor in the counties relative to the national level, localisation coefficients were used. These indicate the importance of an industry in a region, or how specialised the region is in any industry, compared to the national average. The localisation coefficient at point of time *t* for industry *i* in the region *r* is calculated as:

$$LQ_{ri} = \frac{E_{ri}/P_r}{E_i/P}$$

Here E_{ri} represents employment in industry *i* at region *r* and P_r the total employment in region *r*. E_i represents employment in industry *i* at the national level and P total overall employment. An LQ-value of 1 therefore means that the industry has the same representation (or importance) in the region as nationally. An LQ>1 (<1) can be interpreted as meaning that the industry is relatively more important (less important) in the region than nationally.

Our analysis involves the comparison of data for forest-based employment at the municipal level aggregated to Statistics Norway's 101 prognosis regions. Table 1 shows the regions in which the total forest industries are most important. For forestry this is calculated on the basis of national accounts data for normal man-years on the national level (5400) and forest cutting on the municipal level.

Winner and loser regions - shift-share analysis

In this section we look at changes in employment patterns at the regional level, focusing at the upswing in the early 1990s (1990-95).

There are two possible ways of defining employment winner and employment loser regions. By (a) looking at changes in absolute values we will, for industries in general growth, get "large" regions at the top of the winner list, even though these may have had a significantly weaker rate of growth than other regions. The contrasting picture will show large regions topping the list of losers for industries undergoing general recession even though the region has coped relatively speaking better than others. By (b) only looking at relative changes, both winner and loser lists will be easily dominated by regions often categorised as insignificant and of little interest.

One way to combine these methods is to perform a shift-share analysis. This involves splitting changes in absolute value into a structure component which tells us how large the change would have been if an industry in the region had had the same relative change as the national average, and a shift component which is the difference between observed change in absolute value and the structure component. The shift component therefore expresses the lost or gained market share calculated as the number of jobs. If an industry is in general recession, for example, regions that show either progress or a minor decline relative to the national average will have a positive shift component. If the industry is in general growth, the shift component will be positive only if the region has a better percentage development than the national average.

More formally the shift-share model can be written as

Table 1. Regions where forest industries are most significant in employment.

	Localisation coefficient			
Prognosis region	Forest industry total	Forestry	Wood and wood products	Pulp and paper
Flisa	8.3	11.5	13.4	0.0
Hønefoss	6.9	3.8	2.3	14.3
Sarpsborg	6.3	0.3	0.3	17.3
Halden	5.1	2.3	0.3	12.9
Sør-Østerdal	4.6	11.5	3.2	3.0
Egersund	4.5	0.2	9.6	0.0
Selbu/Tydal	4.2	5.9	h8	0.0

$$\frac{E_{ir}(t_2)}{E_{ir}(t_1)} = \frac{E_i(t_2)}{E_i(t_1)} + \left[\frac{E_{ir}(t_2)}{E_{ir}(t_1)} - \frac{E_i(t_2)}{E_i(t_1)}\right]$$

i.e. the representation of industry *i* in region *r* at time t_2 divided by the same representation at time t_1. The first expression on the right hand side of the equation is the structure component and represents the hypothetical relative change of employment between the two periods if region *r* had the same change as the national average. The expression in the braces (which is the difference between observed changes and the structure component) represents thus the shift component. Multiplying out the denominator on the left hand side, we get the expression in absolute values. Table 2 shows the winner and loser regions in manufacture of wood and wood products in the period 1990-95.

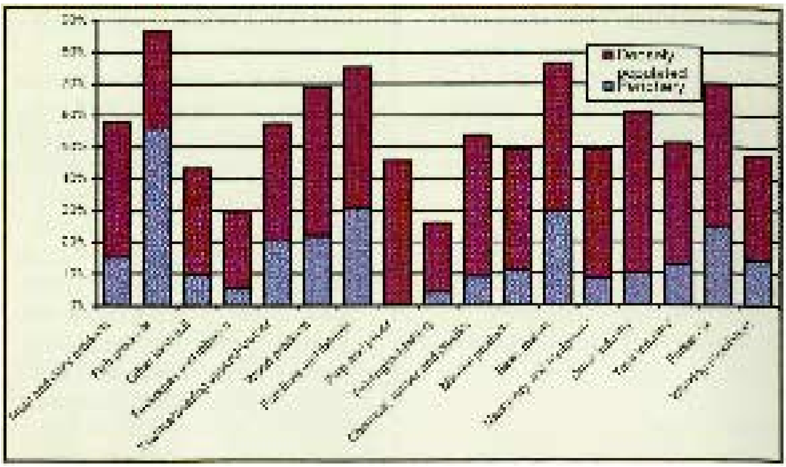

Figure 2. Share of employment and forest cut outside larger urban areas.

Distribution in municipal categories and regional periphery-centre restructuring

So far the discussion has concerned specific geographical regions and therefore only indirectly been able to shed light on questions of the importance of the forest industries in rural Norway. We now turn our attention to whether any regional restructuring has occurred e.g. between the periphery and urban areas, and what the characteristics are of the regions that stand out regarding size, significance and development of forest industries.

As Figure 2 shows, 69% of the employment in manufacture of wood and wood products is outside the larger urban regions, of which 22% is in peripheral areas. The corresponding shares for forestry are 70% and 25% and for pulp and paper industry 46% and 0%.

To illustrate the extent to which a regional restructuring of forest industries has taken place, e.g. between the periphery and the centre, table 3 focuses on changes in the distribution of these industries between various municipal categories, according to centrality, between the years 1980, 1990 and 1995.

From 1980 to 1990, both the peripheral areas and densely populated areas increased their share of employment in the wood and wood products industry at the expense of the large

Table 2. Winner and loser regions in manufacture of wood and wood products 1990-95.

	Employment 1990	Change 1990-1995			
		Percent	Number	Share	Shift
Total	16,266	-16	-2,599	-2,599	1
Winner regions 1990-1995					
Egersund	548	17	92	85	177
Eidsvoll	798	+1	156	-16	172
Asker/Bærum	54	-6	39	-26	132
Kristiansand	342	12	42	-55	96
Trondheim	115	4	15	65	80
Loser regions 1990-1995					
Larvik	552	-39	-216	-125	-104
Kongsvinger	252	-23	242	190	-110
Ski-/Fosnagata	754	38	188	50	138
Oslo-Romerike	786	37	287	178	116
Hamar	1851	-25	-220	-257	-242

Table 3. Employment in forest industries according to centrality, 1980, 1990 and 1995 (%).

		Total	Wood and wood products	Pulp and paper
Periphery	1980	11	18	[illegible]
	1990	17	20	0
	1995	12	22	0
Densely populated areas	1980	27	16	15
	1990	25	49	44
	1995	29	47	46
Larger urban areas	1980	61	25	51
	1990	55	31	55
	1995	46	31	54

urban areas. From 1990 to 1995 too, peripheral areas increased their share of employment in the wood and wood products industry, but this time at the expense of densely populated areas. The pulp and paper industry is almost equally distributed between the large urban areas and densely populated areas. There have been only minor changes in this distribution since 1980.

Conclusions

The forest industries in Norway are, to a much greater degree than most other activities, localised in the rural areas and have the largest share of total employment in the forest areas of Eastern Norway and Trøndelag.

One fundamental question is whether or not there has been a regional restructuring of the forest-based industries, i.e. if the peripheral areas have lost or gained market shares to the central areas in the form of jobs. Although the dramatic recession in the wood and wood products industry has had a larger negative impact on the total employment situation in rural Norway than in central areas, our analysis shows that there is no overall reason to conclude that any centralisation as such has occurred.

It is not necessarily access to natural resources that is crucial to a region's progress. An example of this is the growth in the wood and wood products industry in the Egersund and Farsund regions, which lie in an area of Norway with few forest resources. The explanation of their progress may be that the local business network has been successfully utilised, in combination with formalised knowledge.

In recent years, a number of "value-chain" projects have been carried out in Norway. A joint conclusion from these is that there is large potential for income generation in traditional standard production through e.g. having a better overview of raw material bases, changed timber type specifications, and better communication throughout the value chain.

In-further developing the role of the forest-based industries as employer and income generator in the rural areas, however, this will be of limited importance. In order to maintain and develop the role of forest-based industries, these industries themselves and public authorities must work together to combine formalised knowledge with local skills and traditions. A steady increase in the standard of living will bring with it a growing demand for individualised, niche products. Meeting and adapting to this trend will probably be the greatest challenge facing the forest -based industries in rural Norway.

ANSSI NISKANEN AND PENTTI HYTTINEN

Common framework for farm forestry accountancy in Europe

SAMANTEKT
Um 65% af alls 132,7 milljón ha skóglendis innan Evrópusambandsins eru í einkaeign og þar af eru 23,5 milljónir ha skóga á bújörðum. Í sumum Evrópulanda er timburframleiðsla úr skógum á bújörðum mjög stór hluti af heildarframleiðslunni. Það er því þörf á skilvirkum leiðum til að fylgjast með þessari auðlind og afrakstrinum af henni, bæði fyrir einstaka landeigendur, einstök ríki og fyrir ESB sjálft. Lýst er bókhaldsaðferðum sem nota má í þessu skyni. Þær fela m.a. í sér að notuð eru slembiúrtök í stað þess að reyna að ná til allra og upplýsinga er aflað með spurningalistum eða viðtölum. Síðan eru því sem næst venjulegar bókhaldsaðferðir notaðar til að vinna úr gögnunum. Niðurstöðurnar geta síðan nýst einstökum skógarbændum við ákvarðanatöku um aðgerðir í eigin skógum og ESB við stefnumótun um málefni skógarbænda.

Farm forestry in the European Union

In many contexts, farm forestry includes only forests owned by farmers, excluding remotely owned forests and forest areas owned by people who have their main occupation outside traditional agriculture. In some contexts, a broader definition is used counting even all *non-industrial private forestry* under the term of farm forestry, whereas in other cases a size limit is applied identifying farm forestry with the notion of *small scale forestry.* Especially in the Scandinavian countries, the term *family forestry* has a meaning very close to that of farm forestry.

Privately owned forests account for 65 % of the total forest land area in the European Union (Communication 1998). There are approximately 12 million private individuals that can be classified as forest owners. Their economic importance is underlined by the fact that in most countries privately owned forests play a major role in timber supply for forest industries. A large part of private forest holdings are owned by small-scale family enterprises where farming and forestry activities are combined. According to the EUROSTAT statistics (Forestry ... 1998), the number of *'agricultural holdings with wooded area'* in the EU countries is almost two million covering 23,5 million hectares out of the 132,7 million hectares of total wooded area in the EU.

Despite the fact that several European countries, such as Austria, Germany, the Netherlands and Finland have established monitoring systems for farm forestry enterprises, widely applicable tools to systematically measure and monitor socio-economic sustainability especially at the farm level are still missing. Common to the existing monitoring systems is the idea to collect data on socio-economic variables to help in analysing and adjusting the policies related to farm forestry enterprises.

Accountancy networks

In general, long-term monitoring of the economic performance of farm forestry enterprises is most accurate to implement through *accountancy networks*. In these networks, a sample of farm forestry enterprises is selected using various sampling techniques. The sample farms can be monitored for several accounting periods, or continuously. The typology of the sample can be based on the type of farm; the size of a farm in terms of area or net return; production region or on various site characteristics like quality, difficulty or location. The data and results from similar farms in the sample are combined and generalised for the rest of the such farms in the population.

In monitoring, the first essential problem is related to accounting. Receipts and expenditures must be recorded in a systematic way including often, not only the bookkeeping of financial matters but also the recording of physical quantities of resources and products using specific bookkeeping forms. From the bookkeeping viewpoint, harmonising the calculation procedures for the costs and revenues is one of the most challenging problems in order to make the results from different countries comparable. Characteristically, there are large differences between regions and countries in the procedures applied in timber trade, in the productive capacity of woodlands and in the structure of forest ownership.

Before any decisions are made on the parameters to be monitored, or stratification of the type of holding (by ownership type, size, region, or so on) or the way in which information is to be collected, it is necessary to identify different potential users of the information, the type and quality of information that they will require, and potential sources of information. By identifying these potential users of the monitoring information, it is easier to define the necessary sampling and organisational arrangements.

The second research problem in monitoring the socio-economic situation of farm forestry through accountancy networks, is the problem of statistical validity. Because of the large number of individual farm forest owners and farm forest enterprises, it is not possible in practise to collect comprehensive information on all the farm forest owners. The parameter values for the whole population must be defined by collecting a limited amount of empirical data that can be analysed and generalised.

The problem of statistical validity includes the choice of the sampling method, sampling size and grounds for stratification (e.g. size of the farm forest enterprises, type of farm forest owner, location, etc.). The theory of sampling can be utilised to find answers to these questions.

The first essential piece of information in developing a sample is the information on the population of farm forests. The monitored population has to be described by such features which clearly allow the distinction of the members of the population from non-members. Information on the population characteristics can be found for example from the agricultural census, farm registers, registers documenting ownership or from various other statistics (Sekot 2000a).

For the developed sampling frame, where the population of interest is defined, different sampling techniques can be applied. They include the techniques of random sampling, purposive sampling, quota sampling, systematic sampling and cluster sampling as well as combined techniques. The selection of a sampling technique largely impacts on the costs of sampling, but also on the statistical accuracy, validity and reliability (Sekot 2000a).

The third research problem in the monitoring of the socio-economics of farm forestry, is related to the organisational arrangements. For long term monitoring systems, permanent organisational arrangements, including tasks from planning and application of the existing monitoring systems and principles, up to updating the systems and developing them further, are essential.

Running the network can be in the responsibility of various organisations, e.g. public research institutes, universities, forest authorities, forest owners associations or private companies providing bookkeeping services. The network organiser can organise the collection of data either through questionnaires or through field survey where farms are visited and owners interviewed (Sekot 2000b). The mailed questionnaires are cheaper to use for data collection, but the quality of data is normally better if it was collected through field surveys and interviews. To have reliable accountancy data, the forest owners must have faith in the monitoring system and they need to be assured that the information on forestry income is not used for taxation purposes (Sekot 2000b). This is easier to explain through field survey approach than with mailed questionnaires.

Farm forestry accounting

After the organisational considerations, sample design and respective research work, monetary and physical information on farm forest inputs and outputs can be collected. This data can be processed with forestry accounting where the principles are similar to ordinary financial accounting, with few exceptions. Cost accounting and costing techniques are most closely identified with the production of goods and services, but they are also necessary functions in other areas of activity such as bidding for jobs, making cost-benefit analysis before projects etc. Cost accounting provides information about costs: which the management accountant then uses to plan, control and make decisions (Hakkarainen and Sekot 2000) (Table 1).

Like in any other firms, a farm forestry enterprise's accounting procedure should comprise a profit and loss account (Table 2), a balance sheet (Table 3), as well as those parts of cost accounting that have relative importance for the owner (Hakkarainen and Sekot 2000). In Table 2, the items after the profit (loss) of the period (level 8) do not belong to ordinary financial accounting (Hyder et al. 1994).

Accounting of only the realised revenues and costs is in principle

Table 1. Example of the division of cost centres and types of costs in cost accounting in farm forestry (Hyttinen et al. 1997, pp. 77-83).

Cost centres	Types of costs
• Harvesting;	• material;
• Regeneration;	• wages;
• Clearing, pruning and pre-commercial thinning;	• social costs;
• Protection;	• depreciations;
• road construction;	• administration;
• forest improvement;	• contractors, and;
• administration;	• owners own work.
• taxes and fees; and	
• other costs.	

Table 2. Example of an information needs for profit and loss accounting ('income statement' in the US) for private forestry (see Aho and Rantanen 1994, Committee for corporate analysis 1995, Laitinen 1992, Hyder et al. 1994)

–	Stumpages sales revenue
	Delivery sales revenue
	Other sales revenue from wood
-	Sales of used fixed items
1	TIMBER SALES REVENUE
–	Sales revenue from other than wood
	Sales adjustment items including the value added tax (VAT)
2.	NET TURNOVER
	Variable costs
-	Marketing costs
-	Harvesting costs
	Silvicultural costs exceeding (-) or underutilizing (+) the reserve for regeneration
-	Change in the reserve for regeneration
	Other variable costs
3.	GROSS MARGIN ON SALES (MARGIN AFTER VARIABLE COSTS)
-	Fixed costs
4	OPERATING MARGIN
–	Financial income
	Financial expenses
	Direct taxes
-	Other non-operating expenses
-	Other non-operating income
5	INCOME BEFORE DEPRECIATIONS AND EXTRAORDINARY ITEMS
-	Depreciations
6	NET PROFIT (LOSS)
	Extraordinary expenses
-	Extraordinary revenues
7	OVERALL RESULT
-	Increase/decrease of reserves
-	Increase/decrease (+) depreciation
	Income taxes
8	PROFIT/LOSS OF THE PERIOD
	Adjustment of net interest (±)
-	Change in the value of standing timber (±)
-	Value of owner's own work
9	ADJUSTED PROFIT OF THE PERIOD

simplistic, but not, however, sufficient for accurate assessment of the overall profit of a farm forestry enterprise. Changes in the value of the growing stock, forest owners' own work and joint costs between agriculture and forestry, at least, should be taken into consideration to evaluate the changes in the current assets value (Niskanen 2000, Niskanen and Hyttinen 2000, Niskanen and Sekot 2000).

A simplistic system for data collection and analysis for total economy of the farm would separate the forest from the owner's other entities. However, as in practise these entities often form a single enterprise and they share many resources such as funds, debts, expenses and fixed assets, it is sometimes more practical to jointly assess the various entities of a farm forest enterprise.

Discussion and conclusions

Monitoring of the economics of farm forestry is needed primarily to assess the profitability of forestry as well as the farm level impacts of the changes in economic and political environments. The most recent changes that have or will likely impact on the economics of farm forestry include Agenda 2000, structural development policies, demands for sustainable forestry, changes in national forest policies, forest certification requirements and possible changes in EU's Common Agricultural Policy. The basic problem here is that the farm level impacts of these changes are not possible to estimate without a methodological sound monitoring system.

In order to be able to achieve a wide application of the principles of accountancy networks, the requirements of various stakeholders have to be considered. In doing this, it becomes more possible than previously to provide information on key economic issues for forest owners, forest owners associations, forest advisory organisations, as well as policy makers and researchers by adopting and implementing the presented farm forestry monitoring principles.

As described in Niskanen and Hyttinen (2000), an example of a well functioning accounting network is Farm Accountancy Data Network (FADN), where approximately 58,000 agricultural holdings in the EU member countries are systematically surveyed. As the FADN network has a high coverage of farms in the sample, it logically provides a basis for developing the farm forestry accounting systems in a generic manner.

As the FADN was originally developed to provide monitoring information for Common Agricultural Policy (CAP) implementation, the ability of the FADN to provide information on non-agricultural income like forestry is limited. Often farms with forestry activities are excluded from the FADN farm samples, or revenues

Table 3. Example of an adjusted balance sheet applicable for a farm forestry enterprise (see Teränne 1993, Committee for corporate analysis 1995, Penttinen and Hakkarainen 1998).

1 ASSETS	19 Cash in hand and in bank
10-12 Fixed assets and other capitalised expenditure	1900 [illegible]
10 Intangible assets	1910 [illegible]
1001 intangible assets	1920 [illegible]
11 Tangible assets	1990 other [illegible]
1100 [illegible]	2 LIABILITIES AND CAPITAL
1120 buildings and constructions	20 Capital
1130 [illegible]	2000 capital at the beginning of the accounting period
1140 [illegible]	2010 capital investment
1150 advances paid	2020 [illegible]
1190 other tangible assets	2030 [illegible] for the period
12 Securities and long-term investments	2040 capital return
1200 stocks and shares	2050 [illegible]
1210 other long-term investments	2060 [illegible]
13 Valuation items	21 Capital correction
1300 valuation items	2100 [illegible]
14 Current assets	22 Reserves
1400 [illegible]	2200 [illegible]
1410 [illegible]	2210 [illegible]
1420 [illegible]	23 Long-term liabilities
1490 other current assets	2300 [illegible]
15-16 Financial assets	2310 [illegible] establishment
15 Receivables	2390 other long-term debt
1500 [illegible]	24 Short-term liabilities
1510 [illegible]	2400 trade payables
1520 other [illegible] receivable	2410 advances received from [illegible]
1530 other trade receivables	2420 advances received from sales at delivery price
1540 [illegible]	2430 advances received from [illegible] sales
1550 [illegible]	2440 [illegible]
1560 value added tax receivable	2450 [illegible]
1590 other receivables	2460 [illegible]
	2490 other short-term liabilities

and inputs of forestry activity are excluded in the accounts. Furthermore, often the information on farm returns based on existing FADN survey form does not permit separation of non-agricultural inputs (Brookes 1998).

In practise, a complete farm forestry accounting system under the FADN system is difficult to establish. This is not least for the following two reasons. Firstly, the nature of the activities involved in the growth and management of trees differs fundamentally to that of agriculture. Secondly, the determination of the financial and economic values and quantities of various inputs and outputs, in addition to the assets is not possible to do with the same accuracy in forestry as in agriculture. Nevertheless, the FADN provides the only existing cross-national network for monitoring the socio-economic situation of farms in the European Union. Therefore, it also provides a logical basis for developing the farm forestry accounting systems in the member countries in a harmonised manner.

Establishing an accountancy network is not an easy task with or without being able to use the FADN framework, and it is therefore important to adopt a principle of 'realistic optimism' as a starting point. Nevertheless, since the demand for information of the economic performance of forestry at farm level is increasing, the efforts and resources used for developing of farm forest accountancy networks are justified so as to satisfy the information requirements of various interest groups.

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ÞRÖSTUR EYSTEINSSON

Environmental impact assessment of afforestation in Iceland

SAMANTEKT
í nýlegum lögum um mat á umhverfisáhrifum kemur fram að skógrækt á yfir 200 ha svæði eða á verndarsvæðum kunni að vera háð mati. En er ástæða til að hafa áhyggjur af áhrifum skógræktar á umhverfið og mun mat á umhverfisáhrifum leiða til breytinga a skógræktaraðferðum? Umhverfisáhrif skógræktar má flokka í áhrif á fólk, samfélag og menningu annars vegar og áhrif á náttúrufarsþætti hins vegar. Einnig má flokka áhrifin eftir skala, þ.e, áhrif innan einstakra skógarreita, á landslagsvísu, á landsvísu og á heimsvísu. Áhrif skógræktar á fólk og samfélag eru yfirleitt jákvæð, það sem þarf helst að hafa gát á er að skemma ekki fornleifar. Áhrif skógræktar á náttúrufar geta verið talsverð á minnsta skalanum en eru mun minni á landslagsvísu, hvað þá á landsvísu. Það sem flestir benda á er að skógrækt breytir ásýnd lands, sem hún vissulega gerir, en það er háð smekk hvers og eins hvort sú breyting sé talin jákvæð eða neikvæð. Skógrækt breytir aðstæðum fyrir lífverur sem búa á þeim blettum þar sem skógur verður ræktaður og er því mikilvægt að rækta ekki skóg á fundarstöðum sjaldgæfra lífverutegunda. Hins vegar er skógrækt nær alfarið stunduð á algengustu landgerðum og því er þessi hætta lítil. Þegar upp er staðið munu skrifræðistæki eins og mat á umhverfisáhrifum, leyfisveitingar, válistar og skógræktaráætlanir ekki koma í veg fyrir þau slys sem kunna að verða. Skógræktandanum sjálfum verður að treysta til þess.

Introduction
Environmental impact assessment (EIA) has the combined goals of informing and involving the public in decision making and mitigating negative affects to the environment of the project in question, be it a hydroelectric power plant or afforestation of a small plot of land. The "public" in this case does not include every-body. Besides local government and official agencies or institutions, who may be required by law to express an opinion, the only members of the public who do are individuals or NGOs who for some reason are against the proposed project. People who are in favor of something assent through their silence. EIA legislation therefore empowers the gainsayers, which is necessary since otherwise only those implementing the project, such as government or industry, are empowered. Unfortunately, with empowerment comes the opportunity to abuse power and people who for personal reasons are against something (or someone) can abuse EIA legislation to hinder a project or at least make it more expensive. There is however only one valid reason for calling for environmental impact assessment; concern for the environment.

In the EIA Act passed by the Icelandic parliament in spring 2000, 200 ha is set as the area limit above which planned afforestation might require an EIA. Some institutions would have liked this limit to be considerably lower for a variety of reasons, some of which had nothing to do with concern for the envi-ronment. Some people, however, are doubtless genuinely concerned about the effects increased afforestation might have. So what are these effects that increased afforestation might have on the environment in Iceland and is there reason for concern?

Effects on what?
Environmental effects can be classified into effects on humans and their culture (society, indi-viduals, archaeology, etc.) and effects on nature (biota, biodiversity, soil, water, etc.). They can also be classified according to scale (site level (X), landscape level (β), regional/country level (γ) and global level).

Scale is very important since the effects of afforestation on the

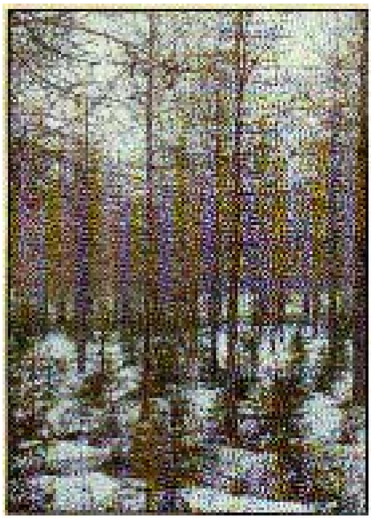


Fig. 1. This was a Kobresia-Empetrurn heath 30 years ago. Obviously, afforestation changes the environment.

Fig. 2. A forest on the other side of the pond does not spoil the view although planting on this side would.

same factor can be quite different, even opposite, from one scale to the next. In general, effects of afforestation will be greatest on the smallest scale, on the individual forest owner or afforestation site. On the community or landscape scale the effects will be variable but generally less. Some areas will see considerable changes due to afforestation, others practically none. On the level of entire regions or the whole country, the goal of afforesting 5% of the land area below 400 m elevation over the next 40 years means that 95% will remain treeless. The environmental impact will likewise be small. By the same token, the effect will be negligible on the global scale.

Effects on humans and culture

It is difficult to find negative effects of afforestation on humans in a land practically devoid of forests. Afforestation supported by government grant schemes provides an added source of income to those land owners, mostly farmers, who participate. This can amount to as much as 3-4 months wages and can in some cases mean the difference between the farm remaining inhabited or not. Jobs are also created in seedling production and a variety of other services connected to forestry. Forests provide a variety of goods and services including shelter, recreational opportunities and even religious experience and it is hoped that a timber resource will eventually develop in some areas. The change in land use leads, at least temporarily, to a reduction in available grazing land but that is each land owner's choice. The existence of a woodlot probably increases property value.

Afforestation obviously changes the look of the landscape, which is a psychological effect on humans. Depending on the type of forest planted, the height, color and texture of the vegetation will change. The plantations will for the most part be individual enclosures, from 20 to 150 ha in area, surrounded by treeless land. Because fences are straight, more or less straight forest edges will form. These can be made "softer" by planting lower growing tree and shrub species towards the forest edge. Changes in the look of the landscape will be the greatest near towns and near farms and fields in densely populated rural communities, less in more sparsely populated rural areas and none outside of populated areas. Whether these changes are seen as positive or negative is a matter of individual taste and is difficult to deal with scientifically in environmental impact assessment. However, forests can hide individual landscape features from view and this must be dealt with in afforestation planning.

There is a danger that afforestation activity can damage archaeological sites through site preparation, through the growth of tree roots or by blow-down of trees. Some say that it is at least as likely that afforestation will help to conserve archaeological sites by preventing erosion. Nevertheless, care must be taken to avoid disturbing sites of archaeological or historical interest with afforestation. This is best done through the afforestation planning process and by educating and informing the tree planters.

Effects on nature

Changes to soil and groundwater chemistry can occur with any change in vegetation. The question then is whether or not these effects are likely to be harmful in some way. Some soil and groundwater chemistry research has been done in Icelandic forests in recent years, with results not indicating any obvious problems. Considering the proposed scale of afforestation, this is a non-issue.

Effects of afforestation on erosional processes are generally positive, since afforestation is often used to help prevent erosion or to revegetate eroded land.

Changes in biodiversity, especially changes to habitats where rare species can be found, is probably the environmental aspect of afforestation that we should be most concerned with. Afforestation changes conditions profoundly at the site level, in some cases leading to nearly complete replacement of the biota on the site. This however depends on what was on the site before-hand and the tree species planted. An eroded site planted to larch will in time regain a similar or higher level of species richness and will certainly be much more productive than before, but it will lose almost all of its original biota, the exceptions being lichens that don't care whether they grow on rocks or on tree bark. Moorland planted to birch will on the other hand retain a large number of species, even shade-intolerant plants. Research is needed to better characterise the biodiversity changes that occur with different afforestation techniques and species. However, one cannot ignore the current state of biodiversity in Iceland. Iceland is depauperate in terms of biodiversity because of its Quaternary history and isolation and biological production is at a minimum because of unsustainable landuse after human settlement. All of the land that will be afforested was wooded at the time of settlement but is now more or less in a state of environmental degradation. The most common cover types, moorland, desertified land and grassland, are also the most common afforestation sites.

Rare species and rare habitat types are, by definition, rare. It is therefore unlikely that they will be disturbed by afforestation. Nevertheless, care must be taken to avoid disturbing such sites. As with archaeological sites, this is best done through the planning process and through education. Design guidelines can also do much to reduce the impact of afforestation on site biodiversity. These include f.ex. planting mixtures of broad-leaved species and conifers rather than pure stands of evergreens, not draining wetlands for afforestation and using native species where appropriate.

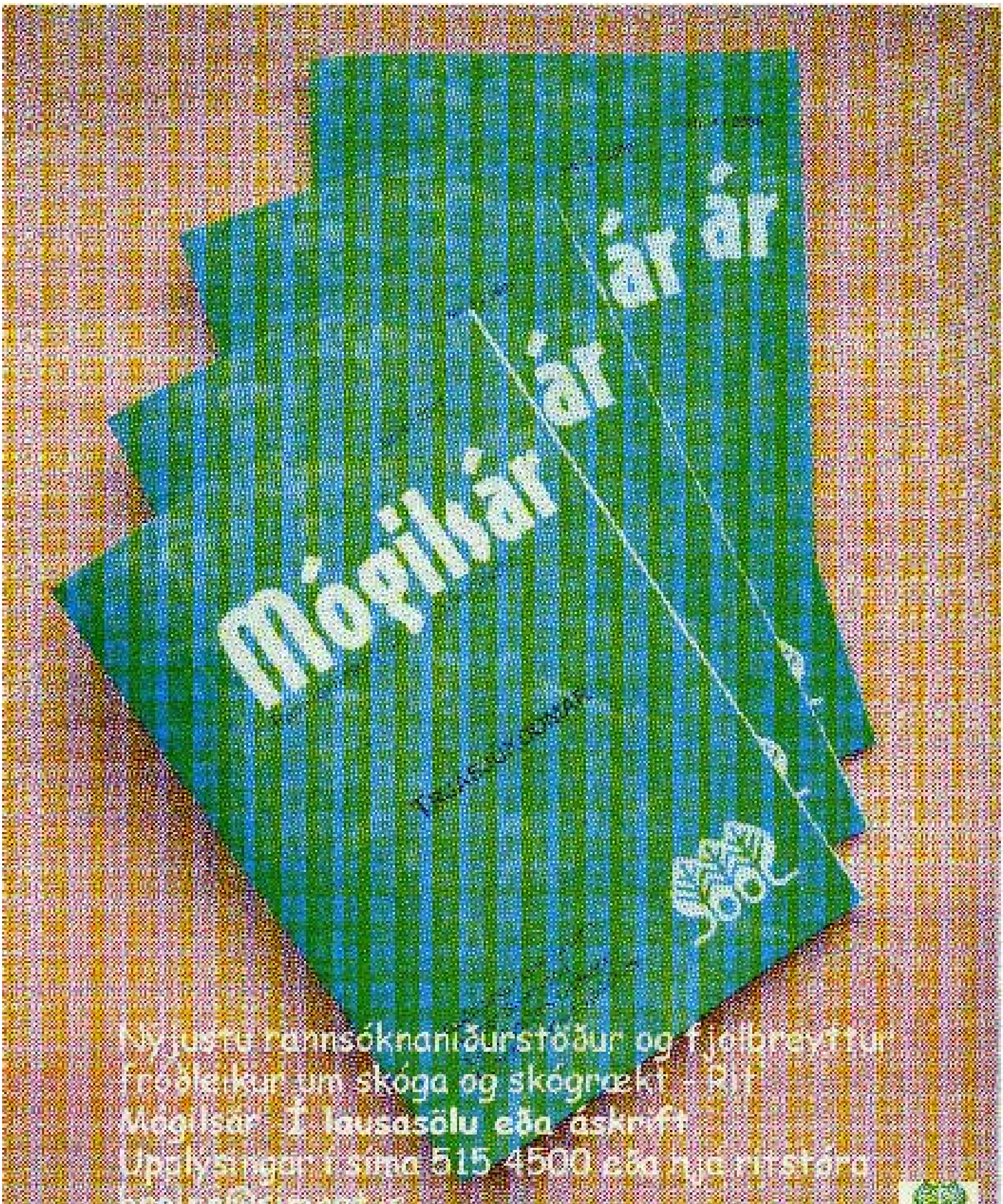
At the landscape level, afforestation leads to increased biodiversity by creating new habitat types. There are no forests in large parts of Iceland and woodland species are uncommon. The new forests will be occupied by a great many species regardless of whether the trees planted are native or exotic. The same applies on the regional level, although the small scale of afforestation efforts in Iceland results in the regional effect being negligible.

Time

Afforestation is not like building a dam or a road where the change happens quickly and is finished. The forest does not exist just because trees have been planted In Iceland, it takes 10-20 years from the time trees are planted until they start affecting their surroundings. All afforestation does is to set ecosystem succession in motion or to change the direction that succession will take. The changes are gradual and continuous. Succession will not be the same at any two places even though you plant the same trees. You cannot state "this is what it will be like when the forest has arrived". Therefore, environmental impact assessment of afforestation is bound to be inaccurate at best and at worst pure fiction. Besides, if history teaches us anything, it is that forests are much more easily destroyed than regrown. Thus, if the environmental effects of afforestation turn out to be unacceptable, all you need is a chain saw to remedy the situation.

Conclusion

Most effects of afforestation are either seen as positive or at least not cause for concern. However, three things stand out as potential reasons for concern: 1) From the point of view of the general public, afforestation leads to landscape change, 2) regarding biodiversity, possible effects on rare species and rare habitat types are more important than effects on biodiversity in general and 3) from a cultural perspective, important archaeological sites must be protected. It is unlikely that EIA of afforestation will result in changes in afforestation planning since the above factors are already taken into account. The existence of bureaucratic devices such as an afforestation plan, list of rare habitats, map of archaeological sites or an EIA report does not guarantee that they will be followed. When all is said and done, it is the individual farmer or tree planter who must bear responsibility for their actions.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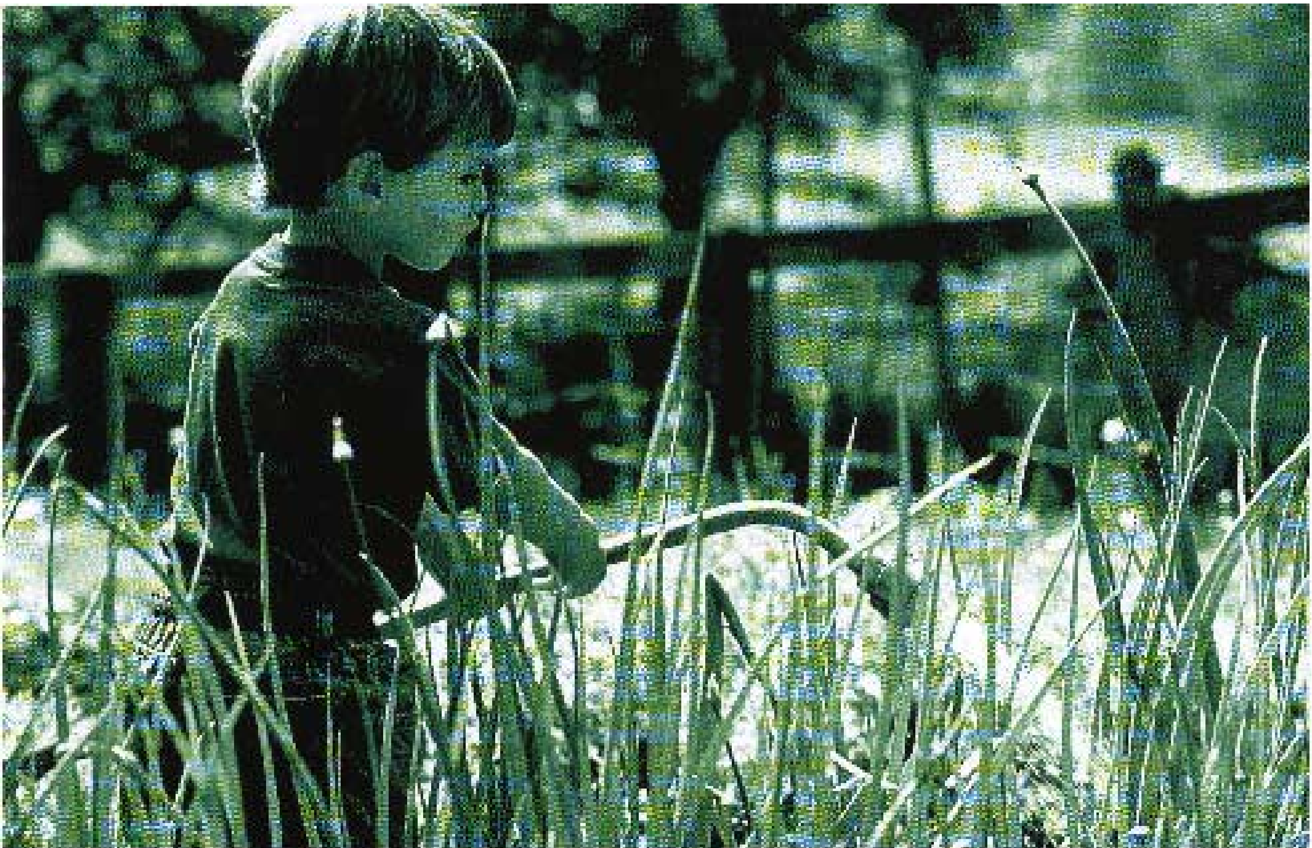

ISSN 0257-9336

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