Bioforsk Rapport
Bioforsk Report
Vol. 8 Nr. 35 2013

ECONADA: ECOlogically sustainable implementation of the 'NAture Diversity Act' (Naturmangfoldloven) for restoration of disturbed landscapes in Norway

Report from the second project year 2012

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Tittel/Title:

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Dato/Date:	*Tilgjengelighet/Availability:*	*Prosjekt nr./Project No.:*	*Saksnr./Archive No.:*
12 Apr. 2013	Åpen / Open	190011	
Rapport nr./Report No.:	*ISBN-nr./ISBN-no:*	*Antall sider/Number of pages:*	*Antall vedlegg/Number of appendices:*
35 / 2013	978-82-17-01064-7	54	2

Oppdragsgiver/Employer:	*Kontaktperson/Contact person:*
Norwegian Directorate for Nature Management (DN)	Gunn Paulsen
Norwegian Water Resources and Energy Dir. (NVE)	Kristin Evjen
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Norwegian Defence Estates Agency	Line S. Selvaag
Feste Landskap	Tone Telnes
E-CO Vannkraft	Ola Gunleiksrud
Norsk frøavlerlag	Jon Midtbø

Stikkord/Keywords:
Økologisk restaurering, frø, biologisk mangfold
Ecological restoration, seed, biodiversity

Fagområde/Field of work:
Ecological restoration

Sammendrag:

Rapporten viser status for ECONADA etter de to første prosjektår, dvs. halvveis i prosjektet.

Summary:

This report shows the status of ECONADA by the end of 2012, i.e. half way through the project.

Godkjent / Approved, 12 April 2013

Ingvar Hage
Director / project responsible /
leader of ECONADA consortium

Trygve S. Aamlid
Project leader

Preface 2012

The four year (2011-2014) project 'ECONADA - ECOlogically sustainable implementation of the 'NAture Diversity Act' (Naturmangfoldloven) for restoration of disturbed landscapes in Norway' was granted by The Research Council of Norway in December 2010.

The project is a joint effort with the following stakeholders:

Public agencies / commercial companies

- Norwegian Directorate for Nature Management (DN)
- Norwegian Water Resources and Energy Directorate (NVE)
- Norwegian Public Roads Administration
- Norwegian National Rail Administation
- Statkraft
- Norwegian Defence Estates Agency
- E-CO Vannkraft
- Feste Landskap
- Norsk frøavlerlag

Norwegian universities / research institutes

- Norwegian Institute for Agricultural and Environmental Research (Bioforsk)
- The Norwegian University of Life Science (UMB)
- Norwegian Institute for Nature Research (NINA)
- Sogn and Fjordane University College (HSF)

International partners

- Sandra Malaval, Conservatoire bot. nat. des Pyrénées et de Midi-Pyrénées, France
- Armin Bischoff, Dépt. Sciences Biologiques, Agrocampus Ouest, Angers, France
- Bernhard Krauzer, Federal Research Institute for Agriculture in Alpine Regions, Austria
- Ása L. Aradóttir, Agricultural University of Iceland

In their meetings on 18 January 2012, the project consortium board and reference group decided that the second project year 2012 should be a working year with no seminars or workshops hosted by the project. Thus, this publication mostly reports on the activity within each of the five work packages (WPs) in 2012. The report has been assembled for mutual exchange of information amongst those involved in the project, and as a basis for discussion in the research consortium and project reference group. It has also been assembled to provide necessary documentation for reports to the Norwegian Research Council.

Bioforsk Øst Landvik, 12 April 2013

Trygve S. Aamlid

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Summary: ECONADA – Status and achievements as of 12 April 2013

Spread of alien seeds after damages to vegetation and landscapes is a serious threat to biodiversity and the environment. The main objective of the whole-chain project ECONADA (2011-14) is to define and produce indigenous seed, to find criteria for successful establishment from seed and clarify the long-term effects of sowing. The project is divided into five workpackages (WP) with corresponding subgoals. The following gives a status of the five WP in relation to subgoals as of 1 April 2013, approximately half way through the project period:

WP 1. Subgoal; To define 10 model species which are important for ecological restoration, and to collect leaf material of each species from 20 collection sites in order to identify genetic variation. Responsible: Trygve S. Aamlid, Bioforsk (WP-leader), Dagmar Hagen, NINA and Siri Fjellheim, UMB.

The collection of leaf material is completed. The following ten model species were chosen: *Poa alpina*, *Phleum alpinum*, *Festuca ovina* ssp. *ovina*, *Avenella flexuosa*, *Agrostis mertensii*, *Luzula multiflora* ssp. *frigida*, *Carex bigelowii*, *Leontodon autumnalis* var. *taraxaci*, *Oxyria digyna* and *Achillea millefolium*. Most collections were collected during the summer of 2011 at sites from the Varanger Peninsula in the north to Setesdal Vesthei in the south, and a final supplementary collection in the summer of 2012. The financial statement shows that the cost of the collection was about 30 per cent higher than budgeted.

WP 2. Subgoal: To define seed-transfer-zones for the ten model species from DNA analyses (AFLP). Responsible: Siri Fjellheim, UMB (WP-leader), Sonja Klemsdal, Bioforsk and Abdelhameed Elameen, Bioforsk.

DNA has been extracted and AFLP profiles generated for all model species except for *Oxyria digyna* and *Achillea millefolium*. The scoring of the profiles was supposed to be performed automatically at Bioforsk, but this results generated by this method have proved to lack reproducibility. Therefore, verification has to be conducted manually, and this is time-consuming. As of 1 April 2013, analyses have been completed for *Avenella flexuosa*, *Festuca ovina* and *Poa alpina* only. For *A. flexuosa* there was no genetic difference between populations from different locations; in other words the whole country is one seed-transfer zone. All collected material of *Festuca ovina* also had the same genetic constitution except for populations from Lyngen and Finnmarksvidda; these exceptions were probably due to sowing or other anthropogenic influence, and it is therefore concluded that whole country should be regarded as one seed transfer zone even for this species. For *Poa alpina* the picture wes more complex with the five groups (1) Setesdal vesthei, (2) Hardangervidda, (3) Strynefjellet, (4) Saltfjellet and (5) the rest of the country. This segregation can probably be attributed to seminiferous and viviparous forms in this partly apomictic species. Tentative data from *Phleum alpinum* suggest one northern and one southern seed transfer zone separated at at Saltfjellet. Analyses of *Agrostis mertinsii, Leontodon autumnalis*, *Carex bigelowii* and *Luzula multiflora* will not be complete fore the growing season 2013, and *Achillea millefolium* and *Oxyria digyna* will probably have to be deleted because of budget deficits.

A scientific publication on genetic variation and seed-transfer-zones for eight species will be completed during 2013. After an oral presentation at the European Conference on Ecological Restoration (ECER) in September 2012, the researchers of WP 2 have been invited to write a chapter in the book "Guidelines for native seed production and grassland restoration", which will be published in 2014 by Cambridge Scholars Publishing. There has been a change in staff as Sonja Klemsdal has left Bioforsk, while Marte Holten Jørgensen is partly employed to work on the project money at UMB. As of 1 Jan. 2013 the financial statement for this WP showed that labor consumption in the first two years was 18% higher than budgeted in Bioforsk, whereas UMB used less working hours than budgeted because of late delivery from Bioforsk.

WP 3. Subgoals: To develop seed production for ecological restoration into a niche production for Norwegian seed growers, and to identify optimal seed crop management and location of seed production. Responsible: Trygve S. Aamlid (WP-leader) and Kristin Daugstad, Bioforsk.

This WP is partly a prolongation of the project FJELLFRØ (2007-11). Commercial production of native seed has been contracted by Bioforsk's seed company to ten growers in Telemark county. After many field trials, especially on weed control, the growers have become successful with seed production of *Festuca ovina, Poa alpina, Phleum alpinum, Agrostis mertensii* and to a certain extent *Avenella flexuosa.* In total for the first four of these species the seed stock is now approximately 10 tons which includes 2-4 populations per species. As the total seed sale in 2012 was only 750 kg, most of the multiplications will now be discontinued and efforts in 2013 and 2014 directed towards the information about correct use of native seed. Just like in WP 2 the project leader for WP 3 will write a chapter in the CAB volume on native seed.

Field trials for the study of optimal location of seed production of different populations of *Poa alpina, Festuca ovina* and *Phleum alpinum* were established in 2011 at Flaten in Alta, Løken in Valdres and Landvik in Grimstad. Preliminary results from 2012 suggest that seed yields of Arctic and Alpine populations become higher if multiplication are moved to areas with longer growing seasons. This is not only due to the climate, but also to more experienced seed growers in the southeastern lowlands. Another seed harvest in 2013 is necessary before a scientific publication can be written in 2014. Labor consumption in WP 3 was 72% higher than budgeted during the two first years of the project, and this requires an adjustment of activities in 2013 and 2014.

WP 4. Subgoal: To clarify the variation in properties related to germination and seedling growth, especially root growth and drought tolerance among and within species relevant for ecological restoration. For* Festuca ovina *a second objective is to study local adaptation to drought in populations growing under different moisture conditions. Responsible: Hans Martin Hanslin (WP-leader) and Knut Anders Hovstad, Bioforsk.

The first part of this WP is mainly on schedule. Experiments on root growth in different species have been completed, scientific publications are, however, delayed, because publications from other authors provide new opportunities for data analysis. In the second part of the WP, plants of *Festuca ovina* have been collected along an east-west gradient at Dovre, but the species could not be found as far west /

near the coast as Åndalsnes. Seed production of collected populations in greenhouses in 2012 failed due to high temperature in the pollination phase but will be repeated in spring 2013.We expect to have sufficient seed and plants for several small trials on local adaptation at Hjerkinn, Oppdal and Skjåk in 2013/14. Financial statement for WP 4 shows labor consumption and other costs according to budget.

WP 5. Subgoal: To clarify the effect of ecological factors on the establishment from seed after various disturbances, as well as criteria for when it is appropriate to sow and the long-term effect of sowing on vegetation development. Responsible: Dagmar Hagen, NINA (WP-leader), Line Rosef, UMB and Knut Rydgren, HiSF (Sogn and Fjordane University College).

In the short-term this WP includes a study of vegetation establishment after sowing *Poa alpina, Festuca ovina* and *Luzula multiflora* ssp. *frigida*, separately and in mixture, on different types of soil in a new trial at Dovre in August 2011. In 2012, this trial included observations of field emergence and plant condition of all species one year after seeding.

In the medium-term the WP includes studies of vegetation establishment and succession on road verges seeded at Dovre in 1990, and in a field trial established by the project FJELLFRØ in Bitdalen, Rauland in 2008. In this part, preliminary observations suggest that sowing of road verges with mixtures dominated by red fescue (*Festuca rubra*) causes permanent vegetation change, while the sowing of mixtures (FJELLFRØ) consisting of native species creates greater diversity and to a lesser degree prevents natural regneration from the seed bank.

In the long-term the WP includes studies of plant succession and differences from of surrounding vegetation on spoil heaps established during the period 1950-2000, above and below the treeline, in Buskerud and Sogn and Fjordane counties. The field work in this part is now finished with the main conclusion that the content of fine particles in the substrate is more important for vegetation than is sowing or fertilization during the first years after establishment. A preliminary version of these results was presented at the ECER Conference in 2013 and a final publication is in preparation.

The financial statement for WP 5 shows that the total costs, primarily for working hours, in 2011 and 2012 was 19% higher than budgeted.

In addition the subgoals for the different WP it is an important goal for ECONADA in 2013 to achieve mutaual exchange of information and to start planning one or several joint scientific or popular publications across the various WP. The project leader group is also planning a joint ECONADA seminar and excursion at Dovre in September 2013.

Sammendrag: ECONADA – Status og måloppnåelse pr 12.april 2013

Spredning av fremmed frø etter naturinngrep en viktig trussel mot biodiversitet og miljø. Hovedmålet med helkjedeprosjektet ECONADA (2011-14) er å definere og produsere stedegent frø, å finne kriterier for vellykka etablering fra frø og klarlegge de langsiktige virkninger av frøsåing. Prosjektet er delt inn i fem arbeidspakker (WP) med tilhørende delmål. I det følgende gis en status for de ulike WP i relasjon til delmåla pr 1.april 2013, dvs. drøyt halvveis i prosjektperioden:

WP 1. Delmål: Å definere 10 modellarter som er viktige for økologisk restaurering, samt å samle inn bladmateriale av disse fra 20 lokaliteter for å kartlegge genetisk variasjon. Ansvarlige: Trygve S. Aamlid, Bioforsk (WP-leder), Dagmar Hagen, NINA og Siri Fjellheim, UMB.

Innsamlinga er fullført. Følgende ti modellarter ble valgt ut: Fjellrapp (*Poa alpina*), fjelltimotei (*Phleum alpinum*), sauesvingel (*Festuca ovina* ssp. *ovina*), smyle (*Avenella flexuosa*), fjellkvein (*Agrostis mertensii*), seterfrytle (*Luzula multiflora* ssp. *frigida*), stivstarr (*Carex bigelowii*), fjellfølblom (*Leontodon autumnalis* var. *taraxaci*), fjellsyre (*Oxyria digyna*) og ryllik *(Achillea millefolium*). Det meste ble samla inn sommeren 2011 på lokaliteter fra Varangerhalvøya i nord til Setesdal vesthei i sør, og en siste supplerenede innsamling ble utført sommeren 2012. Prosjektregnskapet viser at kostnadene til innsamlinga ble ca 30% dyrere enn budsjettert.

WP 2. Delmål: Å definere frøoverføringssoner for de ti modellartene ut fra DNA-analyse (AFLP). Ansvarlige: Siri Fjellheim, UMB (WP-leder), Sonja Klemsdal, Bioforsk, Abdelhameed Elameen, Bioforsk.

DNA er ekstrahert og AFLP profiler generert for alle modellarter unntatt fjellsyre og ryllik. Scoringa av profilene skulle i utgangspunktet utføres automatisk hos Bioforsk, men dette viste seg å gi manglende reproduserbarhet. Både ved Bioforsk og UMB arbeides det derfor nå med manuell verifisering, og dette tar tid. Pr 1.april er derfor bare smyle, sauesvingel og fjellrapp ferdigstilt. For smyle var det ingen sikker genetisk skilnad mellom populasjoner fra ulike lokaliteter, m.a.o. utgjør hele landet en frøoverføringssone. Av sauesvingel hadde alle populasjoner samme genetiske sammensetning bortsett fra populasjonene fra Lyngen og Finnmarksvidda; dette skyldes sannsynligvis frøsåing eller annen menneskig påvirkning, og det konkluderes derfor med at hele landet er en frøoverføringssone også for denne arten. For fjellrapp var bildet mer komplekst med fem grupper: (1) Setesdal Vesthei, (2) Hardangervidda (3) Strynefjellet (4) Saltfjellet og (5) landet forøvrig. Større oppdeling for fjellrapp enn for de andre artene skyldes sannsynligvis apomixis i slekta *Poa*, og at det innafor fjellrapp finnes både frødannende og vivipare former. For fjelltimotei viser den foreløpige analysen to overføringssoner, nemlig en sone fra Saltfjellet og nordover og en felles sone for Sør-Norge. For fjellkvein, fjellfølblom, stivstarr og seterfrytle er arbeidet forsinket slik at kart med frøoverføringssoner ikke kan påregnes før vekstsesongen 2014. På grunn av budsjettsprekk må analysen av ryllik og fjellsyre sannsynligvis utelates.

En vitenskapelig publikasjon om genetisk variasjon og frøoverføringssoner i åtte arter forventes ferdigstilt i løpet av 2013. Etter innlegg ved European Conference on Ecological Restoration (ECER) i september 2012 er forskerne i WP 2 invitert til å skrive et kapittel i boka 'Guidelines for native seed production and grassland restoration' som skal utgis av 'Cambridge Scholars Publishing'.

Det har vært et skifte i personale idet Sonja Klemsdal har slutta i Bioforsk, mens Marte Holten Jørgensen er ansatt I delid på UMB for å jobbe med prosjektet .. Ved årsskiftet 2012/13 viste prosjektregnskpet at arbeidsforbruket i de to første åra var 18% større enn budsjettert i Bioforsk, mens UMB brukte færre timer enn budsjettert på grunn av sein leveranse fra Bioforsk.

WP 3. Delmål: Å utvikle frøavl før økologisk restaurering til en nisjeproduksjon for norske frøprodusenter, samt å finne fram til optimal dyrkingsteknikk og lokalisering av frøavlen. Ansvarlige: Trygve S. Aamlid (WP-leder) og Kristin Daugstad, Bioforsk.

Denne WP er delvis en videreføring av det tidligere prosjektet FJELLFRØ (2007-11). Den kommersielle frøavlen foregår hos ca 10 frøavlere i Telemark på kontrakt med Bioforsks frøforreting. Etter mange dyrkingstekniske forsøk, spesielt med ugrasbekjempelse, behersker nå frøavlerne oppformeringa av sauesvingel, fjellrapp, fjelltimotei, fjellkvein og til en viss grad smyle. Av de fire førstnevnte artene er det bygd opp en frøbeholdning på ca 10 tonn bestående av 2-4 populasjoner pr art. Det totale frøsalget i 2012 var ca 750 kg. Mange av oppformeringene må derfor avsluttes og innsatsen i 2013 og 2014 vil i stedet bli retta mot informasjon om riktig bruk av frøet. Som i WP 2 skal prosjektleder for WP 3 skrive et kapittel til boka 'Guidelines for native seed production and grassland restoration'

Forsøk med lokalisering av frøavl av ulike populasjoner av fjellrapp, sauesvingel og fjelltimotei foregår på Flaten i Alta, Løken i Valdres og Landvik ved Grimstad. Foreløpige resultater 2012 tyder på at frøavlingene av arktiske og alpine populasjoner blir større om oppformeringa flyttes til områder med lengre vekstsesong. Dette skyldes ikke bare klimaet, men også mer erfaring med frøproduksjon på Sørøstlandet. Det er derfor nødvendig med ny frøhøsting i 2013 før vitenskapelig publikasjon skrives i 2014. Arbeidsforbruket i WP 3 var i sum for de to første prosjektåra 72% større enn budsjettert, og en justering av aktiviteten I 2013 og 2014 er derfor nødvendig.

WP 4. Delmål: Å klarlegge variasjon i egenskaper relatert til spiring og frøplantevekst, spesielt rotvekst og evne til å tåle tørke, hos arter som er aktuelle til økologisk restaurering. For sauesvingel er det et delmål 2 å studere lokal tilpasning til tørke hos populasjoner som vokser under ulike fuktighetsforhold. Ansvarlige: Hans Martin Hanslin (WP-leder) og Knut Anders Hovstad, Bioforsk.

Den første delen av denne WP går stort sett etter planen. Forsøk ved rotvekst hos ulike arter er gjennomført, men vitenskapelig publisering er forsinket, bl.a. fordi publikasjoner fra andre forfattere gir nye muligheter for analyse av data. I den andre delen av arbeidspakken er planter av sauesvingel samlet inn langs en øst-vest gradient på Dovre, men det har ikke lyktes ikke å finne sauesvingel så langt vest som ved Åndalsnes. Frøproduksjon av innsamla populasjoner i veksthus i 2012 mislyktes på grunn av høy temperatur i pollineringsfasen men vil bli gjentatt våren 2013. En regner med å ha nok frø og planter til å gjennom flere små forsøk med lokal tilpasning på Hjerkinn, Oppdal og i Sjåk i 2013/14. Totalt forventes tre vitenskapelige publikasjoner innen utgangen av 2014. Regnskapet for WP 4 viser arbeidsforbruk og andre kostnader som budsjettert.

WP 5. Delmål: Å klarlegge virkningen av økologiske faktorer på etablering fra frø etter ulike typer naturinngrep, samt å finne kriterier for når det er nødvendig å så og den langsiktige virkningen av såing på vegetasjonsutviklingen. Ansvarlige: Dagmar Hagen, NINA (WP-leder), Line Rosef, UMB og Knut Rydgren, HiSF.

På kort sikt studeres virkningen av såing av de tre artene fjellrapp, sauesvingel og seterfrytle, alene og i blanding, på ulike jordarter i et nytt forsøk anlagt på Dovre i aug. 2011. Her ble det i aug. 2012 gjort registreringer av spiring og kondisjon i alle rutene. På mellomlang sikt studeres vegetasjonsetablering og suksesjon langs veikanter tilsådd på Dovre i 1990, og i et forsøk anlagt av prosjekt FJELLFRØ i Bitdalen i Rauland i 2008. Her viser foreløpige observasjoner at såing av veiskråningsblandinger dominert av rødsvingel medfører varig endring i vegetasjonen, mens såing av norsk fjellfrøblanding gir større artsmangfold og i mindre grad hindrer etablering fra den lokale frøbanken. På lang sikt studeres plantesuksesjon og skilnad fra omgivende vegetasjon på steintipper anlagt i perioden 1950-2000, både over og under tregrensa i Buskerud og Sogn og Fjordane. I denne delen er feltarbeidet avslutta, og viktigste konklusjonen er at tilgangen på finstoff i substratet er mer avgjørende for vegetasjonen enn om det det ble sådd eller gjødsla de første åra etter etablering. En foreløpig versjon av disse resultater ble presentert på ECER-konferansen i 2013 og det arbeides nå med sluttpublisering. Regnskapet for WP 5 viser at de totale kostnadene, først og fremst til arbeid, i 2011 og 2012 oversteg budsjettet med 19 %.

Foruten arbeidet i de ulike WP er det i 2013 et mål for ECONADA å få til større utveksling av informasjon og å planlegge minst en felles vitenskapelig eller populærvitenskapelige publikasjon på tvers av de ulike WP. Prosjektet vil også invitere til seminar og ekskursjon på Dovre i september 2013.

WP 1: Definition of model species and collection of leaf material for DNA extraction

Siri Fjellheim, Dagmar Hagen and Trygve S. Aamlid

As shown in last year's report from ECONADA, collection of leaf material of 20 individuals of each of ten model species (Table 1) from 20 collection sites (Fig. 1) was almost completed in 2011. Among the 26 gaps in the map from 2011, ten gaps were filled with supplementary collections at Meråker, Kvikne/Tynset and Ringebufjellet ion 2012. For the other sites it was considered a waste of time to try to find the missing species as they probably do not grow in the area. Thus, Table 2 shows the final result from this WP.

Fig. 1. Collection areas.

Table 1. Model species

	Norwegian name	Scientific name
1	Fjellrapp	*Poa alpina*
2	Fjelltimotei	*Phleum alpinum*
3	Sauesvingel	*Festuca ovina* ssp. *ovina*
4	Smyle	*Avenella flexuosa*
5	Fjellkvein	*Agrostis mertensii*
6	Seterfrytle	*Luzula multiflora* ssp. *frigida*
7	Stivstarr	*Carex bigelowii*
8	Fjellfølblom	*Leontodon autumnalis* var. *taraxaci*
9	Fjellsyre	*Oxyria digyna*
10	Ryllik	*Achillea millefolium*

Table 2. Results from collection of ten model species in 20 areas

	Poa alpina	*Phleum alpinum*	*Festuca ovina*	*Avenella flexuosa*	*Agrostis mertensii*	*Luzula frigida*	*Carex bigelowii*	*Leontodon autumnalis*	*Oxyria digyna*	*Achillea millefolium*
1) Øst Finnmark	OK	OK	OK	OK	OK	OK	OK	OK	OK	OK
2) Finn-marksvidda	÷	÷	OK	OK	OK	OK	OK	OK	OK	OK
3) Ytre est-finnmark	OK	OK	OK	OK	OK	OK	OK	OK	OK	OK
4) Lyngen	OK	OK	OK	OK	OK	OK	OK	OK	OK	OK
5) Lofoten/ Vesterålen	OK	OK	÷	OK	OK	÷	÷	OK	OK	OK
6) Ofoten/ Bjørnefjell	OK	OK	OK	OK	OK	÷	OK	OK	OK	÷
7) Salt-fjellet	OK	OK	OK	OK	OK	OK	OK	OK	OK	OK
8) Børge-fjell	÷	OK	÷	OK	OK	÷	OK	OK	OK	OK
9) Meråker	OK*	OK	OK	OK	OK*	OK*	OK	OK	OK*	OK
10) Kvikne/ Tynset	OK	OK	OK	OK	OK*	OK*	OK	OK	OK*	OK
11) Troll-heimen	OK	OK	OK	OK	÷	OK	OK	OK	OK	OK
12) Dovre-fjell	OK	OK	OK	OK	OK	OK	OK	OK	OK	OK
13) Stryne-fjellet	OK	OK	÷	OK	OK	OK	OK	OK	OK	OK
14) Vika-fjellet	OK	OK	÷	OK	OK	OK	OK	OK	OK	OK
15) Valdres flya	OK	OK	OK	OK	OK	OK	OK	OK	OK	OK
16) Ringe-bufjellet	OK*	OK	OK	OK	÷	OK*	OK	OK	OK*	OK
17) Hardanger-vidda vest	OK	OK	OK	OK	OK	OK	OK	OK	OK	OK
18) Hardanger-vidda øst	OK	OK	OK	OK	OK	OK	OK	OK	OK	OK
19) Norefjell	OK	OK	OK	OK	OK	OK	OK	OK	÷	OK
20) Setesdal vesthei	OK	OK	÷	OK	OK	OK	OK	OK	OK	OK
TOTAL	18	19	15	20	18	17	19	20	19	19

*Sampled summer 2012

WP 2: DNA extraction, AFLP analyses and seed transfer zones

Siri Fjellheim, Abdelhameed Elameen, Marte Jørgensen and Sonja Klemsdal

The first step in WP 2 is DNA extraction. As of February 2013, extraction has been finsihed for all samples of eight of the ten model species. The remaining species, *Oxyria digyna* and *Achillea millefolium*, may have to be sacrificed for economical reasons.

The second step is AFLP analysis. This has been completed for five species: *Poa alpina, Festuca ovina, Avenella flexuosa, Phleum alpinum, Carex bigelowii* and *Leontodon autumnalis.* It has also been completed for *Agrostis mertensii* and *Luzula multiflora*, except for supplementary populations collected in 2012.

The third step, scoring of the AFLP profiles, has been more difficult and time-consuming than expected in the planning process. Automatically scored profiles have had low reproducibility, thus requiring manual verificaton. As of 1 April 2013, analyses have been completed for *Avenella flexuosa*, *Festuca ovina* and *Poa alpina* only. Tentative results also exist for *Phleum alpinum.*

- ***Avenella flexuosa***
  The analyses suggest that that *Avenella flexuosa* is one genetic group. This is consistent with the results of a project at the University of Tromsø by Inger Greve Alsos, who has performed AFLP analysis on a large number of circumboreal populations of *Avenella flexuosa*. The preliminary conclusion is that Norway is one seed transfer zone for this species.

- ***Festuca ovina***
  The analyses suggest that we have three genetic groups for *Festuca ovina*. Two of these groups (#2 Finnmarksvidda and #44 Lyngen) consist of only one population each, whereas the remaining populations form the third group. It is likely that the two divergent populations have been introduced by human activity since *Festuca ovina* has been used in seed mixtures. Therefore, these two populations should not define their own zones for seed-transfer. There are populations from the main group south as well as north of the two divergent populations. Thus, our preliminary conclusion is that all parts of Norway make up one seed-transfer zone for *Festuca ovina.*

- ***Poa alpina***
  Apart from the fact that it is apomicitic, *Poa alpina* is a complex species with several subspecies. We suspect that collectors have not distinguished between the subspecies *vivipara* and *alpina.* We have excluded one population (#15 Valdresflya) and some individuals (e.g. about 50% of the genotypes of #1 Varanger) that are so divergent that we suspect they belong to ssp. *vivivpara*. Of the remaining populations, we have five groups; three consisting of one population each (#7 Saltfjellet, #13 Strynefjellet and #20 Setesdal Vesthei), one consisting of the populations from Hardangervidda (17 and 18) and one consisting of the remaining 15 populations. Different populations may have varying degrees of vegetative and outcrossing strategies, and this leads to rapid changes in differentiation depending on the extent of gene flow between populations. For further revegetation-work it should be considered whether this species is suitable or not because of the complex multiplication method.

- ***Phleum alpinum***
  The preliminary results show that we have two genetic groups of *Phleum alpinum*, one northern and one southern. The borderline between the two groups is at Saltfjellet. However, these results are only based on two combinations of primers, and they need to be confirmed by further analyses.

The scientific approach taken in this WP was presented in an oral presentation by Siri Fjellheim at the 8th ECER conference. This resulted in an invitation to write a chapter for a book of Native Seed Production to be published by CAB International in 2013.

Marte Holten Jørgensen has been employed by UMB and has started working on a scientific paper from the project. Abdelhameed Elameen will have poster presentation of WP2 in Plant Genomics Congress in London-Uk 13-14 May 2013.

WP 3. Optimal location for seed production, seed crop management and commercialization.

Kristin Daugstad and Trygve S. Aamlid

WP 3 is split into three subpackages, one dealing with optimal locations for seed production, one with seed crop management and one with seed multiplication and commercialization

Optimal location for seed production

The objective of this subpackage is to investigate adaptation with respect to climatic requirements for seed yield and quality, i.e. to what extent Arctic or Alpine populations must be grown for seed in their area of adaptation or whether seed production can be moved to lowland areas further south.

During the summer of 2011 seed production trials with three important species for restoration were established at three locations (Table 3 and Fig. 2). These three locations represented the south, the mountains and the north, and cover the regions we will investigate. For economical reasons, new trials in 2012 were only established at Løken.

For all species, we used populations that had been collected from 2005 to 2008 and propagated for one generation through the project 'FJELLFRØ'. At each location six populations and one cultivar of *Festuca ovina*, seven populations of *Phleum alpinum* and four populations of *Poa alpina* (Table 4) were sown in a randomized design with three or four replications. One of the *Festuca* populations, 'Avzze' (from Finnmarksvidda) turned out to be *rubra rubra* and not *ovina*, but it was still included in the study.

Table 3. Experimental sites.

Location	Latitude	Elevation	Established	Local responsible
Flaten, Alta	70°N	20 m	7-8 July 2011	NLR Vest Finnmark
Løken, Valdres	61°N	550 m	15 July 2011	Bioforsk
Landvik, Grimstad	58°N	10 m	23 June 2011	Bioforsk
Løken, Valdres	61°N	550 m	22 June 2012	Bioforsk

Table 4. Populations included in seed production location study

Festuca ovina	Phleum alpinum	Poa alpina
Lillian (cultivar)	08/12 Saltfjellet	08/11 Saltfjellet
Hjerkinn	07/60 Kongsvoll	05/L9 Kvikne
05/L7 Kvikne	08/74 Strynefjellet	05/18 Vikafjellet
05/II Høvringen	05/17 Vikafjellet	08/56 Bykle
05/41 Sør Fron	05/60 Åkerstølen	
05/55 Hol	05/73 Fallet	
Avzze*	07/01 Haukeli	

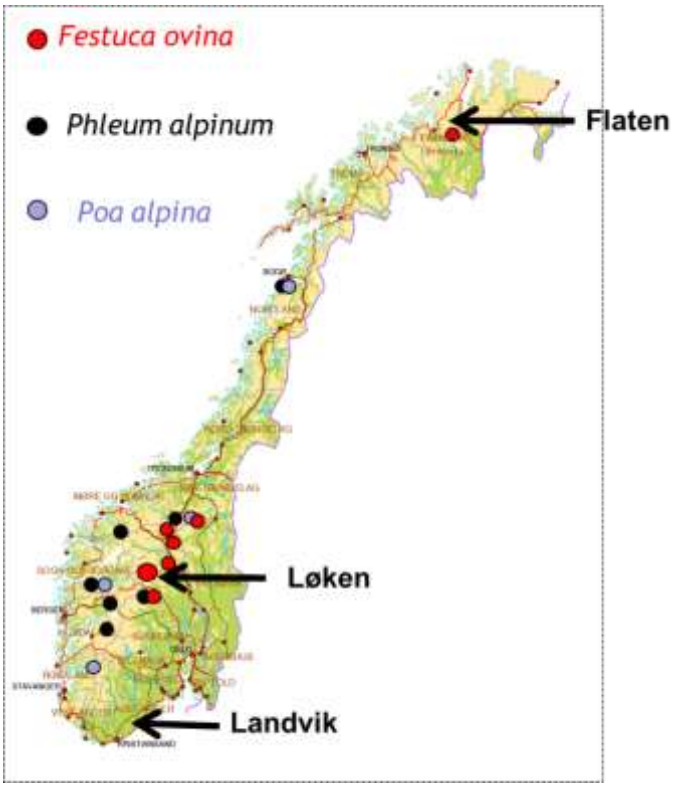

Fig. 2. Geographical origin of populations, and trial sites for location of seed production.

General remarks of the season 2012

At Flaten in Alta there was a lot of winter damage, especially in *Festuca ovina*. No winterkill was recoreded at Løken and Landvik.

During the season 2012 we recorded ground cover, plant height and time of ear emergence. Ear emergence of the grasses investigated was much earlier than of commercial species, and had to be observed from early May (*Poa* at Landvik) until late June (*Festuca* at Flaten). The seed yield components: number of generative shoots, length and weight of 100 panicles, seed yield and thousand seed weight were also recorded.

The seed was threshed with field plot combiners at Landvik and Løken while the whole yield at Flaten was cut, dried and sent to Landvik for threshing. The right time for threshing/harvesting of the seed is crucial for seed yield and quality. Landvik had a great advantage due the staff's long experience with seed production. At Løken and Flaten there is still a lot to learn about seed production. The significant statistical effects of "Location" are therefore not only due to climatic conditions, but also to different experience with seed crop management.

Fig. 3. The trial with *Phleum alpinum* 21 May 2012 at Løken. There was only minor winter damage, but the regular meadow in the background was in an even better condition.

Fig. 4. *Poa alpina* on 29 May at Løken. The first populations started heading 20 May. This photo shows the population 'Vikafjellet'.

Fig 5. The trial with *Festuca ovina* on 29 May 2012 at Løken. The plots with the lightest green color are 'Avzze', a northern population of *Festuca rubra rubra.*

Fig. 6. *Phleum alpinum* flowering at Landvik.

Results from the study of *Phleum alpinum* populations in 2012.

Earlier experience has shown large effect of spraying with fungicide in *Phleum alpinum* seed crops. Therefore, the trials in *Phleum alpinum* followed a split-plot-design with fungicide treatment (Delaro, 1.0 liter = 175 g a.i. trifloksystrobin + 150 g a.i. protioconazole per ha) on large plots and populations on subplots. The effect of fungicide application was significant at Landvik, but not at Løken and Flaten. Diseases were observed at all locations, but more at Landvik (Figs. 7 & 8) than at Løken and Flaten.

Fig. 7. *Phleum alpinum* at Landvik on 1 September 2012. To the left plots without fungicide, to the right with fungicide treatment.

Fig. 8. *Drechslera phleii* in *Phleum alpinum* at Landvik.

Table 5 shows more generative shoots at Løken than at Landvik. Some of the explanation can be that the registration at Løken was made on the best parts of the plot, to avoid badly established parts due to the very wet and difficult year of 2011. The smaller number of generative shoots at Flaten was partly due to strong competition from weeds.

The populations '07/06 Kongsvoll' and '07/01 Haukeli' produced the highest seed yield at Landvik. In terms of generative shoot number and/or weight per panicle, '07/06 Kongsvoll' was also among the better populations at Løken and Flaten. '05/73 Fallet, Ulvik' and '08/12 Saltfjellet' had low seed yields at both Landvik and Løken. The interaction location x population was significant for seed yield, but the practical interpretation of this must await results from one more seed harvest year.

Table 5. Results from Landvik, Løken and Flaten, *Phleum alpinum*.

	Ground cover spring	Plant height in spring	Plant height sum.	Heading day after	Numb. gener. shoots	Seed yield	Weight per unthreshed panicle	Ground cover autumn	Diseases autumn
	%	cm	cm	30 Apr.	no/m^2	kg/ha	mg	%	%
Landvik									
1 08/12 Saltfjellet	71,0	14,6	40,8	9,0	756	198	157	57,0	21,0
2 07/06 Kongsvoll	78,7	14,9	40,8	9,3	909	362	189	64,2	26,2
3 08/74 Strynefjellet	70,0	14,5	41,0	5,5	916	247	181	62,7	22,0
4 05/17 Vikafjellet	78,5	14,4	44,6	17,5	979	268	168	76,3	19,2
5 05/73 Fallet, Ulvik	59,7	14,6	39,7	7,7	763	181	165	52,2	19,3
6 05/60 Åkerstølen	73,7	14,3	40,6	8,3	849	259	158	67,5	22,5
7 07/01 Haukeli	78,0	16,8	44,6	9,7	939	345	182	62,8	25,7
Mean without fungicides	67,7	14,8	41,5	9,7	851	193	166	54,5	42,5
Mean with fungicides	78,1	15,0	42,1	9,5	906	345	179	72,7	2,2
Mean Landvik	**72,9**	**14,9**	**41,8**	**9,6**	**879**	**269**	**172**	**63,6**	**22,3**
Løken									
1 08/12 Saltfjellet	80,0	12,5		29,0	1482	48	100		
2 07/06 Kongsvoll	80,0	12,8		29,2	1665	71	124		
3 08/74 Strynefjellet	67,5	12,6		29,0	1371	79	116		
4 05/17 Vikafjellet	88,8	13,6		32,8	1783	43	98		
5 05/73 Fallet, Ulvik	73,8	12,0		29,0	1339	50	131		
6 05/60 Åkerstølen	83,3	12,1		29,0	1824	52	100		
7 07/01 Haukeli	83,3	13,1		29,0	1208	56	131		
Mean without fungicides	78,9	12,5		29,6	1475	55	113		
Mean with fungicides	80,2	12,9		29,7	1591	60	117		
Mean Løken	**79,5**	**12,7**		**29,6**	**1535**	**57**	**115**		
Flaten									
1 08/12 Saltfjellet	66,8		20,0	63,0	360	22	86	67,8	0,5
2 07/06 Kongsvoll	72,5		19,3	60,8	460	63	107	75,5	1,7
3 08/74 Strynefjellet	70,5		18,3	61,7	373	56	106	69,3	1,5
4 05/17 Vikafjellet	74,2		17,2	63,3	425	45	91	81,2	3,5
5 05/73 Fallet, Ulvik	65,0		21,0	61,0	280	28	97	71,0	2,3
6 05/60 Åkerstølen	61,7		17,7	63,5	429	41	98	66,0	0,8
7 07/01 Haukeli	73,8		21,2	62,3	289	29	107	76,2	3,3
Mean without fungicides	65,8		19,6	62,2	375	43	104	73,5	3,9
Mean with fungicides	72,9		18,8	62,3	373	40	95	71,9	0,2
Mean Flaten	**69,3**		**19,2**	**62,2**	**374**	**42**	**99**	**72,7**	**2,0**
Significans (GLM)									
Fungicide	-	-	-	-	-	***	-	-	***
Location	*	*	***	***	***	***	***	-	***
Fungicide x Location	-	-	-	-	-	***	*	*	***
Population	***	-	*	***	***	***	***	***	-
Fungicide x Population	-	-	-	-	-	-	-	-	-
Location x Population	-	-	***	***	***	*	-	-	-

Results from the study of *Festuca ovina* populations in 2012.

The statistical analyses (GLM) showed significant differences among populations of *Festuca ovina* for most characters observed in 2012. *Festuca rubra* 'Avzze' was not included in the analysis, but the mean scores are shown in the table. Since 'Avzze' is a red fescue both plant height, number of generative shoots and weight of panicles were very different from the sheep's fescues. The significant difference between locations was mainly due to the great winter damage at Flaten. This damage was caused by the fungus *Typhula ishikariensis,* which affected 'Avzze' to a much lesser extent than the sheep's fescues.

Table 6. Results from Landvik, Løken and Flaten, *Festuca ovina* (and *F.rubra* 'Avzze')

	Ground cover spring	Plant height spring	Plant height sum-mer	Heading day after	Numb. gener. shoots	Seed yield	Weight per unthreshed panicle	Ground cover autumn	Diseases autumn
	%	cm	cm	30 Apr	n/m^2	kg/ha	mg	%	%
Landvik									
1 Avzze*	96,0	6,8	76,3	19,0	2349	930	67	81,3	1,5
2 Lillian	95,0	10,6	59,9	20,0	6422	1077	23	82,8	2,0
3 Hjerkinn	72,5	9,0	50,9	8,5	2617	554	27	79,0	1,5
4 05/L7 Kvikne	91,3	8,8	47,9	8,5	3440	552	24	86,3	2,3
5 05/41 Sør-Fron	80,5	7,5	51,7	11,5	3192	625	21	82,3	2,0
6 05/55+56 Hol	91,0	11,3	55,6	11,5	3507	744	35	92,3	2,0
7 05/II Høvringen	70,0	7,8	47,6	12,0	2869	552	28	79,3	2,3
Mean	**85,2**	**8,8**	**55,7**	**13,0**	**3485**	**719**	**31**	**83,3**	**1,9**
Løken									
1 Avzze*	95,3	10,7		32,8	1498	336	64		
2 Lillian	92,5	10,7		29,5	8071	443	21		
3 Hjerkinn	89,3	12,4		27,5	5434	393	28		
4 05/L7 Kvikne	92,0	13,0		28,3	5164	278	20		
5 05/41 Sør-Fron	92,3	12,2		28,0	5846	382	23		
6 05/55+56 Hol	90,3	15,0		27,5	4732	446	32		
7 05/II Høvringen	91,0	12,2		27,3	5238	284	26		
Mean	**91,8**	**12,3**		**28,7**	**5141**	**366**	**31**		
Flaten									
1 Avzze*	72,5		56,5	51,8	493	31	84	87,5	3,8
2 Lillian	18,3		29,0	53,5	468	8	31	42,5	2,5
3 Hjerkinn	13,8		24,5	51,8	403	8	28	30,0	3,0
4 05/L7 Kvikne	20,0		22,0	52,0	224	2	38	32,5	0,5
5 05/41 Sør-Fron	21,3		28,0	50,3	444	6	27	39,5	1,3
6 05/55+56 Hol	20,0		31,0	53,5	456	5	31	39,8	3,5
7 05/II Høvringen	8,8		23,3	50,0	200	0	26	17,5	3,8
Mean	**24,9**		**30,6**	**51,8**	**384**	**9**	**38**	**41,3**	**2,6**
Significans (GLM)									
Population	***	***	***	***	***	***	-	-	-
Location	***	***	***	***	***	***	*	***	-
Location x Population	*	***	-	***	***	***	-	-	-

The highest seed yield at both Landvik and Løken were obtained from 'Lillian' and '05/55+56 Hol'. 'Lillian' is a registered cultivar based on germplasm collected in Valdres, and it was in a class on its own as regards number of generative shoots. The interactions location x population were significant for most characters and will have to be examined more carefully as we get data from one more harvest year.

Fig. 9. From the study of *Festuca ovina* at Flaten. Alta. Weeds took over as *Festuca ovina* died due to winter kill.

Fig. 10. Counting generative tillers at Løken. This plot had 400 generative shoots along a 0.5 meter row.

Fig. 11. Counting of generative shoots was very laborious and demanded regular exercise to avoid pain in the back. Løken, July 2012.

Fig. 12. *Festuca ovina* at Landvik. *Festuca rubra* 'Avzze' is number two from the left. It was taller, but less dense then the ovinas.

Results from the study of *Poa alpina* populations in 2012.

In spring 2012 the trial in *Poa alpina* at Løken was considered not sufficiently established to give a correct picture of the seed production capacity of the different populations in 2012. The trial at Flaten was also of low quality. Thus, ranking of populations had to be based on data from Landvik which showed higher seed yield of '05/L9 Kvikne' and '08/56 Bykle' than of '08/11 Saltfjellet' and especially '05/18 Vikafjellet'. The latter population was characterized by very uneven ripening of seed (Fig 14).

Table 7. Results from Landvik, Løken and Flaten, *Poa alpina*.

	Ground cover spring	Plant hight spring	Plant height sum.	Heading day after	Numb. gener. shoots	Seed yield	Weight per unthreshed panicles	Ground cover aut.	Diseases aut.
	%	cm	cm	30 Apr.	n/m^2	kg/da	mg	%	%
Landvik									
1 08/11 Saltfjellet	77,5	10,1	39,8	6,5	1298	479	68	88,0	23,8
2 05/L9 Kvikne	83,8	12,3	44,5	4,8	1457	626	86	85,0	23,8
3 05/18 Vikafjellet	70,0	12,0	44,3	2,0	1253	346	84	74,3	20,0
4 08/56 Bykle	89,0	11,6	45,1	9,0	1418	576	70	87,3	37,5
Mean	**80,1**	**11,5**	**43,4**	**5,6**	**1356**	**507**	**77**	**83,6**	**26,3**
Løken									
1 08/11 Saltfjellet	70,0	8,0		24,5					
2 05/L9 Kvikne	72,5	8,7		22,5					
3 05/18 Vikafjellet	68,8	8,3		20,3					
4 08/56 Bykle	63,8	8,8		25,3					
Mean	**68,8**	**8,5**		**23,1**					
Flaten									
1 08/11 Saltfjellet	37,0		38,5	51,8	388	166	119	64,0	2,5
2 05/L9 Kvikne	73,8		36,8	51,8	493	384	102	78,8	4,0
3 05/18 Vikafjellet	58,8		36,5	49,5	878	320	102	68,5	4,8
4 08/56 Bykle	31,8		33,7	56,0	348	73	93	68,0	2,8
Mean	**50,3**		**36,5**	**52,0**	**549**	**236**	**104**	**69,8**	**3,5**
Significans (GLM)									
Population	**	-	-	***	-	***	***	-	-
Location	***	***	***	***	***	***	*	-	***
Location x Population	***	-	-	-	*	***	***	-	-

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Fig. 13. *Poa alpina* at Landvik on 22 June. '08/56 Bykle' to the left and '05/L9 Kvikne' to the right.

Fig. 14. Seed ripening of Poa alpina 'Vikafjellet' was very uneven at Landvik.

Seed quality

Seed germination and thousand seed weight is currently being analysed in the seed lab. at Landvik (Tables 8-10). To limit costs these analyses are done by badging the different replications and making one analysis per population and location. Seed from direct combining and recombining of the straw are analysed separately.

As of 25 Feb. 2013, only the analyses of seed produced at Landvik have been completed. Germination was adequate except for seed from the second (re-)combining of *Poa annua*, which also had very low seed weight (Table 10).

Table 8. Germination and thousand seed weight of *Phleum alpinum* populations harvested in the first direct combining and in the recombining of straw in 2012.

		Phleum alpinum	Germination		Thousand seed weight	
			First, direct combining	Second, recombining	First, direct combining	Second, recombining
			%	%	mg	mg
Landvik	1	08/12 Saltfjellet	93,5	96,0	427	371
	2	07/06 Kongsvoll	93,5	95,5	410	374
	3	08/74 Strynefjellet	94,0	94,5	423	364
	4	05/17 Vikafjellet	94,0	98,5	398	338
	5	05/73 Fallet, Ulvik	92,0	92,0	415	365
	6	05/60 Åkerstølen, Hol	91,5	93,0	419	363
	7	07/01 Haukeli	92,0	90,0	426	344
	mean Landvik		**92,9**	**94,2**	**417**	**360**
	mean without fungicide		93,7	93,7	405	354
	mean with fungicide		92,1	94,7	428	365
Løken	1	08/12 Saltfjellet	91,0	83,0	404	389
	2	07/06 Kongsvoll	85,5	79,0	409	378
	3	08/74 Strynefjellet	85,0	88,5	408	386
	4	05/17 Vikafjellet	87,0	87,5	390	385
	5	05/73 Fallet, Ulvik	87,0	77,5	403	374
	6	05/60 Åkerstølen, Hol	82,0	81,0	380	349
	7	07/01 Haukeli	85,5	81,5	408	370
	mean Løken		**86,1**	**82,6**	**400**	**376**
	mean without fungicide		84,9	80,0	404	370
	mean with fungicide		87,4	85,1	396	381
Flaten	1	08/12 Saltfjellet	98,0		408	
	2	07/06 Kongsvoll	98,0		404	
	3	08/74 Strynefjellet	96,5		417	
	4	05/17 Vikafjellet	95,0		384	
	5	05/73 Fallet, Ulvik	94,0		380	
	6	05/60 Åkerstølen, Hol	98,0		382	
	7	07/01 Haukeli	96,5		398	
	mean Flaten		**96,6**		**396**	
	mean without fungicide		97,0		394	
	mean with fungicide		96,1		398	

Table 9. Germination and thousand seed weight of *Festuca ovina* populations harvested in the first direct combining and in the recombining of straw in 2012.

		Festuca ovina	Germination		Thousand seed weight	
			First, direct combining	Second, recombining	First, direct combining	Second, recombining
			%	%	mg	mg
Landvik	1	Avzze (*F. rubra*)	94,0	92,0	812	821
	2	Lillian	69,0	82,0	361	372
	3	Hjerkinn	88,0	84,0	436	446
	4	05/L7 Kvikne, Tynset	78,0	81,0	400	424
	5	05/41 Sør-Fron	89,0	88,0	383	445
	6	05/55+56 Hol	73,0	88,0	430	498
	7	05/II Høvringen	87,0	80,0	463	466
	mean Landvik		**82,6**	**85,0**	**469**	**496**
Løken	1	Avzze (*F. rubra*)	88,0		899	
	2	Lillian	74,0		352	
	3	Hjerkinn	77,0		451	
	4	05/L7 Kvikne, Tynset	76,0		423	
	5	05/41 Sør-Fron	72,0		418	
	6	05/55+56 Hol	88,0		489	
	7	05/II Høvringen	73,0		487	
	mean Løken		**78,3**		**503**	
Flaten	1	Avzze (*F. rubra*)	80,0		973	
	2	Lillian	45,0		441	
	3	Hjerkinn	72,0		522	
	4	05/L7 Kvikne, Tynset	74,0		477	
	5	05/41 Sør-Fron	79,0		430	
	6	05/55+56 Hol	71,0		506	
	7	05/II Høvringen	66,0		511	
	mean Flaten		**69,6**		**551**	

Table 10. Germination and thousand seed weight of Poa alpina populations harvested in the first direct combining and in the recombining of straw in 2012.

		Poa alpina	Germination		Thousand seed weight	
			First, direct combining	Second, recombining	First, direct combining	Second, recombining
			%	%	mg	mg
Landvik	1	08/11 Saltfjellet	95,0	42,0	417	243
	2	05/L9 Kvikne	82,0	55,0	432	275
	3	05/18 Vikafjellet	84,0	67,0	398	294
	4	08/56 Bykle	76,0	34,0	431	268
	mean Landvik		**84,3**	**49,5**	**420**	**270**
Flaten	1	08/11 Saltfjellet	89,0		553	
	2	05/L9 Kvikne	95,0		548	
	3	05/18 Vikafjellet	75,0		477	
	4	08/56 Bykle	48,0		402	
	mean Flaten		**76,8**		**495**	

Seed crop management

The activity in this subpackage has concentrated on weed control in seed crops of *Avenella flexuosa*, *Phleum alpinum*, and *Agrostis mertinsii.*

Avenella flexuosa

Earlier pot and field trials showed that *Poa annua* and other grass weeds in seed crops of *Avenella flexuosa* can be controlled by Boxer (active ingredient prosulfocarb) in the sowing year or by Atlantis WG (iodsulfuron + mesofulfuron) in the sowing year and/or in the seed harvest year . There are, however, examples showing the both Boxer and Atlantis are too tough if applied when seedlings of *A.flexuosa* are are less than 4 cm high in the sowing year. Thus, the objective of this research was to find out rates of these herbicides that control the grass weeds without being too harsh on *A. flexuosa.*

Field trial, Landvik 2011-12

Materials and methods

Avenella flexuosa '07/20 Norefjell' was seeded on a loam soil at Landvik on 2 Aug.2011, sowing rate 10 kg/ha and sowing depth 1 cm. The experimental area was not fertilized before seeding.

The following factorial split plot trial was established on 26 Aug., after field emergence (*A. flexuosa* 4 cm high).

Main plot: Fertilizer:

A. No fertilizer
B. 30 kg N/ha in calcium-nitrate on 26 Aug. 2011.

Subplot: Herbicides :

Treatm.	Application 30 Aug. 2011	Application 2 May 2012
1	Ariane S, 1.92 L/ha	Ariane S, 1.92 L/ha
2	Boxer, 1.0 L/haa	Ariane S, 1.92 L/ha
3	Boxer, 2.0 L/daa	Ariane S, 1.92 L/ha
4	Atlantis, 69 g/ha + R[3]	Ariane S, 1.92 L/ha
5	HussarOD[2], 50 ml/ha + R	Ariane S, 1.92 L/ha
6	Ariane S, 1.92 L/ha	Atlantis, 69 g/ha + R

[1]Active ingredients: fluoxypyr + chlopyralid + MCPA (control treatment with effect on dicot weeds only).
[2]Active ingrdient iodsulfuron
[3] R = Renol (rapeseed oil), 0.5 L/ha

Fig. 15. shows development of *Avenella flexuosa* at herbicide application on 2 May 2012.

Plant response to fertilizer and herbicides was recorded on 23 Sep. and 16 Nov. 2011 and on 31 May 2012. Only observations from 31 May 2012 will be presented here. Due to very few panicles, the trial was not harvested for seed.

Fig. 15. Plant development of *Avenella flexuosa* at herbicide application on 2 May 2012.

Results

Assessment on 31 May 2012 showed that application of nitrogen shortly after field emergence gave more coverage of *Avenella flexuosa* and *Poa annua*, but less coverage of dicot weeds (especially *Matricaria matricarioides*, species not specified in Table 11). Boxer and Atlantis in the sowing year were equally effective in controlling *Poa annua*, but Atlantis tended to give better control of *Alopecurus geniculatus*. Doubling the rate of Boxer in the sowing year or the use of Atlandtis in the seed harvest year reduced plant coverage of *A. flexuosa* to about 50% compared with the control treatment that received Ariane S for broadleaved weed control only.

Table 11. Effect of herbicide application on 30 Aug. 2011 and 2 May 2012 on plant coverage on 31 May 2012 in experiment *Avenella flexuosa* '07/20 Norefjell'

Application 30 Aug. 2011	Application 2 May 2012	Bare soil	*Avenella flexuosa*	*Poa annua*	*Alopec. geniculatus*	Other grass weeds[1]	Broad-leaved weeds[2]
Ariane S, 1.92 L/ha	Ariane S, 1.92 L/ha	10	16	43	12	9	10
Boxer, 1.0 L/ha	Ariane S, 1.92 L/ha	14	15	15	5	6	47
Boxer, 2.0 L/ha	Ariane S, 1.92 L/ha	30	9	12	5	5	41
Atlantis, 69 g/ha + R	Ariane S, 1.92 L/ha	34	12	11	0	4	40
HussarOD, 50 ml/ha + R	Ariane S, 1.92 L/ha	21	17	34	0	15	14
Ariane S, 1.92 L/ha	Atlantis, 69 g/ha + R	42	7	20	4	4	23
P-value		0.018	>0.20	0.002	0.076	>0.20	0.043
LSD 5%		18	-	14	-	-	26

[1]Mostly *Agrostis capillaris* and *Phleum pratense* [2]Mostly *Matricaria matricarioides*

Field trial, Landvik 2012-13

Materials and methods

Avenella flexuosa '08/145 Stranda' was seeded on a coarse sandy soil at Landvik on 28 June 2012. Field emergence was observed on 10 July. The trial received 40 kg N/ha in Fullgjødsel NPK 22-2-12 on 16 Aug. and was sprayed with Ariane S (fluoxypyr + chlopyralid + MCPA), 2.5 l/ha on 21 Aug. Unfortunately, the application of Ariane S had very little effect on some large plants of red clover which therefore had to be hand-weeded on 29 Aug.

Herbicides were applied for the first time on 5 Sep. At this stage, plants of *A.flexuosa* had up to ten tillers and were about 5 cm high.

The experimental design was a randomized complete block with four replicates. The following treatments were compared:

Treatm.	Application 5 Sep. 2012	Application spring 2013
1	Unsprayed	Atlantis, 69 g/ha + R
2	Unsprayed	Atlantis, 138 g/ha + R
3	Boxer, 1.0 L/daa	
4	Boxer, 2.0 L/daa	
5	Atlantis, 69 g/ha + R	
6	Atlantis, 138 g/ha + R	

Results

This trial will be finished with seed harvest in 2013, but the assessment of coverage on 1 Nov. 2012 showed that Atlantis was slightly more effective than Boxer in controlling *Poa annua* (Table 12). The lower rate appeared to be sufficient for both herbicides.

Table 12. Effect of herbicides application on 3 Sep. 2012 on plant height and coverage of Avenella flexuosa seeded without cover crop on 28 June 2012.

Treat-ment	Application 2012	Planned application for spring 2013	Plant height, *Avenella flexuosa,* 1 Nov. 2012	Coverage, 1 Nov. 2012				
				Bare soil	*Avenella flexuosa*	*Poa annua*	Other grass weeds	Broad-leaved weeds
1	Unsprayed	Atlantis, 69 g/ha +R	5.7	50	31	12	1	7
2	Unsprayed	Atlantis, 138 g/ha +R	5.0	59	22	10	1	8
3	Boxer, 1.0 l/ha		4.4	60	23	8	0	9
4	Boxer, 2.0 l/ha		4.8	54	26	14	0	6
5	Atlantis, 69 g/ha +R		4.4	68	22	5	1	5
6	Atlantis, 138 g/ha +R		4.5	64	24	7	0	5
P-value			>0.20	0.14	0.14	0.07	>0.20	>0.20

Fig. 16. From the field trial 2012-13 with different herbicides to a newly established seed crop of *Avenella flexuosa.* Observe rows with *Avenella flexuosa* Photo was taken on 8 Oct. 2012.

Discussion – recommendation to seed growers

As will appear from the later chapter on 'Commercialization', not only *Poa annua* and *Alopecurus geniculatus*, but also *Festuca ovina* and *Poa pratensis* are troublesome weeds in seed multiplication of *Avenella flexuosa*. Especially for *Festuca ovina*, the problem seems to be due to contamination of first generation seed lots, perhaps even some of the basic collections.

The results from the field trials conducted at Landvik in 2011-12 and 2012-13 confirm that Boxer and Atlantis are good choices for control of grass weeds in the sowing year. Early application usually gives better weed control, but *Avenella flexuosa* has to be well established and at least 3-4 cm high at application. Boxer is the best choice if seed lots are contaminated with *F.ovina*.

Neither Boxer nor Atlantis control broadleaved weed which therefore have to be controlled first by a low rate of Ariane S at an earlier stage. Light soils, a sowing depth of approximately 1 cm and and light dressings of fertilizer shortly after field emergence are measures that promote the early growth and development of *Avenella flexuosa* in order that the herbicide program can start early enough.

Phleum alpinum

Pot experiments in 2007 and 2008 suggested that grass weeds in seed production of *Phleum alpinum* can be controlled with Boxer (prosulfocarb) in the sowing year and/or by Hussar OD in the sowing year or seed harvest year. *Phleum alpinum* is, however, sensitive to too high rates of Hussar OD, and there may also be difference among populations in the regard. Experiments in *Phleum pratense* suggest that auumn applications of Atlantis in the sowing year might be an alternative to Hussar OD in the spring. Thus, the objective of this research was to find the optimal combination of these herbicides in seed production of *Phleum alpinum.*

Materials and methods

A field trial was laid out on 21 July 2011 in a seed crop of *Phleum alpinum* '05/17 Vikafjellet' seeded on 22 June by Arne Svalastog, Telemark. The experimental plan appear form Table 13 and comprised two applications in the sowing year and one application in the spring of the seed harvest year.

Observations in the sowing year have been reported in May 2012 (Bioforsk Report 7(76)). The trial was combined directly with a field plot combiner on 16 July 2012.

Results and discussion

Result are shown in Table 13 and Figs. 17 and 18. They can be summarized as follows:

1. Boxer wiped out most plants of *Phleum alpinum* and should definitely be avoided.
2. Hussar was more efficient than Ariane S in controlling broadleaved weed in the sowing year. Addition of Renol rapessed oil to Hussar improved control of broadleaved weeds (mainly *Nasturtium officinale*) but did not improve control of *Poa annua* or other grass weeds. .
3. Better control of brodleaved weeds gave more space for grass weeds, especially *Poa annua*. The only way to counteract this effect was the application of a high rate of Atlantis in autumn. However, this application delayed seed maturation and was more detrimental to seed yield than application of a 50 ml/ha of Hussar OD in the spring of the seed harvest year.
4. Application of 100 ml/ha of Hussar in the spring of the seed harvest year was too tough for the seed crops. 50 ml/ha seems more appropriate.

Table 13. Effect of herbicides in the sowing year and seed harvest year on plant height, seed yield and seed quality of *Phelum alpinum* '05/17 Vikafjellet' in 2012. (Within each column figures followed by the same letter are not significantly different accoring to Duncan's multiple comparison test)

Treatm.	Application 21 July 2011[1]	Application 9 Sep. 2011[2]	Application 9 May 2012[3]	Plant height 6 June 2012	Seed yield, kg/ha	% clean-out	% purity	Thou-sand seed weight mg	% grass weeds	% broad-leaved weeds
1	Unsprayed	Unsprayed	Unsprayed	45 a	385 a	56 c	94.1	353 b	0.38 c	4.70
2	Ariane S, 1.92 L/ha			44 ab	374 ab	55 c	97.7	340 b	0.63 bc	1.77
3	Hussar OD, 0.05 L/ha			44 a	364 ab	54 c	98.8	353 b	0.60 bc	0.57
4	Hussar OD, 0.05 L/ha +R[4]			44 a	330 bc	54 c	94.5	357 b	0.67 bc	0.23
5	Boxer, 2.0 L/ha			10 d	33 d	71 a	43.1	386 a	2.27 a	31.90
6	Ariane S, 1.92 L/ha	Atlantis WG, 69 g/ha+R		42 abc	340 abc	56 c	99.6	342 b	0.60 bc	0.47
7	Ariane S, 1.92 L/ha	Atlantis WG, 138 g/ha+R		41 bc	298 c	57 c	99.4	348 b	0.25 c	0.30
8	Ariane S, 1.92 L/ha		Hussar OD, 0.05 L/ha +R	43 ab	328 bc	57 c	98.9	361 b	0.80 bc	0.07
9	Ariane S, 1.92 L/ha		Hussar OD, 0.10 L/ha +R	40 c	294 c	62 b	98.6	358 b	1.43 ab	0.03
10	Hussar OD, 0.05 L/ha +R		Hussar OD, 0.05 L/ha +R	43 ab	353 ab	56 c	99.2	354 b	0.63 bc	0.03
P%				<0.001	<0.001	<0.001	<0.001	0.054	0.019	0.039

[1] *Phleum alpinum* 3 cm high. [2] *Phleum alpinum* 18 cm high on unsprayed plots [3] *Phleum alpinum* 18 cm high on unsprayed plots [4] R = Renol (rapeseed oil), 0.5 L/ha

Fig. 17. Seed grower Arne Svalastog in the experimental field on 3 July 2012. The predominant broadleaved weed on unsprayed control plots was *Nasturtium officinale.* Photo taken on 3 July 2012.

Fig. 18. Spring application of Hussar OD (100 ml / ha + Renol) in the seed harvest year resulted in faster seed maturation (left), whilst autumn application of Atlantis (138 ml / ha + Renol) in sowing year had the opposite effect (right). Photo taken on 3 July 2012.

Recommendation to seed growers

The best way to control *Poa annua* in seed crops of *Phleum alpinum* is to make an application of Hussar OD, 50 ml/ha, when timothy plants at least 3 cm high. Adding Renol rapeseed oil makes little difference for herbicide tolerance of *Phleum alpinum* or control of *Poa annua*, but it may improve the efficacy of Hussar OD on broadleaved weeds.

In well established seed crops there is also a possibility for a second application of Hussar OD in the spring of the seed harvest year, but such an applications should only be accomplished if grass weeds are still a problem and the rate of Hussar OD must not exceed 50 ml/ha.

Agrostis mertensii

Unlike the situation in *Festuca ovina*, *Poa alpina*, *Avenella flexuosa* and *Phleum alpinum*, we did not have any results from pot trials when starting field trails with weed control in *Agrostis mertensii.* Results from the related species *Agrostis capillaris* suggested a certain tolerance to Hussar OD, at least in the seed harvest year.

Materials and methods

A field trial was laid out on 28 July 2011 in a seed crop of the population '08/41 Strynefjellet' seeded on 28 June by Tronn Kløcker, Telemark. The experimental plan appear from Table 14. It comprised two applications in the sowing year and one application in the spring of the seed harvest year.

Obervations in the sowing year were reported in May 2012 (Bioforsk Report 7(76)), but a few key figures are repeated in Table 14 along with results for seed yield and purity. The trial was harvested directly with a field plot combiner on 17 July 2012.

Fig. 19. From trial in *Agrostis mertensii*. Plot dominated by *Matricaria matricarioides* in foreground had total damage to *A.mertensii* due to application of Boxer one month after seeding. Next plot was rather unmature after application of a high rate of Atlantis in autumn. Occasional plants of *Phleum pratense* had been wiped out with Roundup. Photo taken on 3 July 2012.

Results and discussion

Results are shown in Table 14 and Fig. 19. They can be summarized as follows:

- Boxer one month after seeding killed most plants of *Agrostis mertinsii* and caused plots to be dominated by *Matricaria matricarioides* (Fig. 19).
- As shown by plant height and coverage, the early application of Atlantis also resulted in some injury of *A.mertiensii*, but in this case plants recovered and gave the numerically highest seed yield in 2012. For the early application, Hussar OD must neverthess be regarded as a safer alternative. In comparison with Altantis, it also has the advantage of not only controling grasses, but also broadleaved weeds .
- Ariane S one month after seeding followed by a high rate of Atlantis three months after seeding also resulted in adequate weed control, but seed ripening was delayed compared with the other treatments (Fig. 19).
- *Agrostis mertensii* tolerated Hussar OD in the seed harvest year, even at rate of 100 ml + 500 ml of Renol rapeseed oil per ha.

Table 14. Effect of herbicide program on plant height, coverage, seed yield and purity of cleaned seed of *A.mertensii* '08/41 'Strynefjellet' in 2011-12.

Treatm.	Application 28 Jul.2011 (*A.mertensii* 3 cm high)	Application 16 Sep. 2011 (*A.mertensii* 11 cm high)	Application 2 May 2012 (*A.mertensii* 10 cm high)	Plant height, cm		Coverage, *A. mertensii*		Seed yield, kg/ha (100% purity, 12% water)	Purity of cleaned seed		
				22 Aug. 2011	25 Oct. 2011	25 Oct. 2011	6 June 2012		% *A. mer-tensii*	% broad-leaved weeds	% grass weeds
1	Ari S, 1.92			13	12	83	81	424	96.1	2.9	0.5
2	Boxer, 2.0			4	9	5	18	77	55.6	26.8	2.8
3	Atlantis WG 0.069+R			9	9	76	91	515	98.7	0.2	0.0
4	Hussar OD, 0.05+R			12	11	85	90	473	99.4	0.1	0.1
5	Ari S, 1.92	Atllantis WG, 0.069+R		13	12	83	91	390	98.8	0.1	0.3
6	Ari S, 1.92	Atlantis WG, 0.138+R		12	10	80	89	438	98.0	1.0	0.1
7	Ari S, 1.92		Atlantis WG, 0.069+R	12	10	82	88	458	99.3	0.0	0.0
8	Ari S, 1.92		Hussar OD, 0.10	12	10	81	87	478	99.3	0.0	0.1
9	Ari S, 1.92		Hussar OD, 0.05+R	12	12	82	90	447	98.3	0.0	0.2
10	Ari S, 1.92		Husssar OD, 0.10+R	12	10	82	89	497	98.6	0.2	0.1
P%				<0.1	4	<0.1	<0.001	<0.001	0.012	0.023	>0.20
LSD 5%				1	2	6	14	147	21.7	14.3	-

Recommendation to seed growers

In conclusion, we recommend that Hussar OD can be applied at a rate of 50 ml/ha + Renol oil to control both broadleaved weeds and grass weeds when newly established crops of are at least 30 cm high. If seedlings of *A.mertensii* are smaller and establishemnt less complete, we recommend to make a first application with Ariane S to control broadleaved weeds. Grass weeds can then either be controlled by Atlantis (138 g/ha + Renol) in the autumn of the sowing year or by Hussar OD (138 ml/ha + Renol) in the spring of the seed harvest year.

First and second generation multiplications in 2012 – seed available in 2013

Seed multiplication of local propulations is conducted in two steps. Table 17 shows results from first generation multiplications harvested at Landvik in 2012on seed beds covered by black plastic. As these seed lots are going to be used by the growers in Telemark for sowing of larger fields, it is important that the seed is as clean as possible. For the grasses purity was mostly OK, except for four small lots, two of *Phleum alpinum* , one of *Luzula frigida* and one of *Avenella flexuosa*, that will have to discarded because of a too high weed content. Another three lots of *Avenella flexosa* had to high contents of weed to be used for further multiplications but can be 'used as is' in mixtures for revegetation.

Germination was mostly acceptable except for *Anthoxanthum odoratum* ssp. *taraxaci* and some seed lots of *Avenella flexuosa* that may have been harvested too early of with too high drum speed or too narrow concabve cleareance of the field plot combiner (Table 15).

Unlike in the former project FJELLFRØ which was entirely focused on grzsses and rushes, the first generation multiplications at Landvik in 2012 also included *Leon todon autumninalis* var. *taraxaci* and *Oxyria digyna*, i.e. two of the herbs chosen for genetic analyses in WP 2. Due to their uneven ripening (Figure 20), these herbs were harvested several times, usually by hand or scissors, but for *L. autumninalis* also using the field plot combiner. Seed yield and quality at the different harvest times are shown in Tables 15 and 16. For *L. autumninalis* there was a clear correlation between thousand seed weight and germination, Table 15 suggesting that the most efficient way to harvest seed of this species might be to combine it gently in once most of the seeds are mature in late July.

Fig. 20. Uneven ripening in *Leontodon autumnialis* '08/04 Geilo at Landvik in July 2012.

Table 15. Seed yield and quality of *Leontodon autumnalis* var. *taraxaci* '08/04 Geilo' harvested on multiple dates at Landvik in 2012.

Date	Harvest method	Seed yield, grams	Seed yield, kg/ha	% purity	% weed content	Thousand seed wt., mg	% germi-nation
13.jul	By hand	10	1.3	96.3	0.66	874	81
17.jul	By hand	6	0.7	96.3	0.46	864	80
27.jul	Combining in field	155	20.7	93.4	0.37	869	82
28.jul	Recombining in field	25	3.3	72.5	0.37	653	50
30.jul	Shed on floor from straw taken inside	188	25.1	87.3	0	656	40
30.jul	Recombining of straw taken inside	56	7.5	28.5	0	779	62
Total/weighed mean (to Table 16)		439	59.0	81.4	0.17	754	60

Within *Oxyria digyna* the population from Bykle had higher seed yield, higher thousand seed weight and better germinatin than the population from Vikafjellet. However, as seen from the harvest dates in Table 16, this this might also reflect that harvests in late June of '08/71 Bykle'was more optimal than harvests in eary June and early July, which happened to be practised somewhat inadvertenly for' 08/71 Vikafjellet'.

Table 16. Seed yield and quality of two populations of *Oxyria digyna* harvested on multiple dates at Landvik in 2012.

a) 08/68 'Vikafjellet'

Date	Harvest method	Seed yield, grams	Seed yield, kg/ha	% purity	% weed content	Thousand seed wt., mg	% germi-nation
03.jun	By hand	104	17.3	91.4	0	674	35
13.jun	By hand	40	6.7	46.5	0	955	50
05.jul	By hand	39	6.5	90.3	0	684	41
09.jul	By hand	14	2.3	79.6	0	735	34
11.jul	By hand	22	3.7	83.8	0	678	17
Total / weighed mean		219	37	81.5	0	731	37

b) 08/71 'Bykle'

Date	Harvest method	Seed yield, grams	Seed yield, kg/ha	% purity	% weed content	Thousand seed wt., mg	% germi-nation
15.jun	By hand	30	20.0	90.6	0	909	84
20.jun	By hand	39	26.0	99.0	0	877	78
27.jun	By hand	60	40.0	80.0	0	793	77
Total		129	86	88.2	0	845	79

Figure 21. Single plant of *Oxyria digyna* '08/71 Bykle' at Landvik 20 May 2012.

Second generation, 'commercial seed production is carried out by seed growers in Telemark county as a continuation of the project 'FJELLFRØ'. Table 18 shows the results from these multiplications in 2012. The total seed yield was about 5.2 tonnes. Including seed stored from previous year, about 11 tonnes of seed are available for sale in 2013. The total seed sales in 2012 was only 750 kg. In other words, the seed growers have become quite successful and production will have to be reduced dramatically to reach a better balance between suppy and demand.

Figure 22. Grower Hans Ole S. Erikstein in seed crop of *Avenella flexuosa* '08/145 Stranda', 3 July 2012.

Table 17. Seed harvested in first generation multiplications at Landvik in 2012.

Collect-ion no	Species	Lab. no	Collection site	Multipli-cation field, Landivk	Year of estab-lish-ment	Area of seed field m2	Seed harvest date	Seed harvest method	Seed yield, grams	% purity	Thous. seed weight mg	Ger-mina-tion %	Total weed content and predominant weeds	Remark
05/65	*Anthoxantum odoratum var. taraxaci*	114	Ulvik	Låvekroken	2009	110	27 June	Combiner	163	86.1	403	40	Total 1.42%. *Alopecurus geniculatus, Phleum pratense, Poa alpina, Festuca rubra, Poa annua, Agrostis capillaris*	OK
		115				110	11 July	Combiner	108	76.1	259	16	Total 0.48%. *Avenella flexuosa, Phelum pratense, Poa trivialis, Festuca ovina*	OK
08/04	*Leontodon autumnalis var. taraxaci*	102,111, 112,113 129,130	Geilo	Gustavs	2011	75	13-28 July	By hand + Combiner	439	81.4	754	60	*Total 0.17%: R. acetocella, Spergula arvensis, Stellaria media, P. pratense, P.annua* See Table 16	OK
08/68	*Oxyria digyna*	134-139	Vikafjellet	Gustavs	2011	60	3 June – 11 Jul.	By hand	219	81.5	731	37	Total /weighed mean for harvests. No weeds. See Table 16.	OK
08/71	*Oxyria digyna*	131,132, 133	Bykle	Fidja II	2011	15	15-27 June	By hand	129	88.2	845	79	Total /weighed mean for harvests. No weeds. See Table 16.	OK
08/74	*Phleum alpinum*	106	Strynefjellet	Gustavs	2011	50	28 June	Combiner	191	95.2	412	98	Total: 4,22%. *Poa annua, Alopecurus geniculatus, Rumex acetocella, Cerastium arvense Poa trivialis*	Discard
07/60	*Phleum alpinum*	103	Kongsvold	Låvekroken	2010	230	26 June	Combiner	1274	98.1	455	97	Total: 1.30%. *Poa annua, A. geniculatus, Avenella flexuosa, Cerastium arvense*	OK
		104					28 June	Combiner	450	92.0	412	99	Total: 1.26%. *Alopecurus geniculatus, Festuca ovina*	
08/12	*Phleum alpinum*	105	Saltfjellet	Fidja II	2009	53	27 June	Combiner	205	92.9	459	99	Total: 6.90%. *Poa pratensis, Phleum pratense, Alopecurus geniculatus, Cerastium arvense*	Discard

Table 17. continued

Collect-ion no	Species	Lab. no	Collection site	Multipli-cation field, Landivk	Year of estab-lish-ment	Area of seed field m2	Seed harvest date	Seed harvest method	Seed yield, grams	% purity	Thousand seed weight mg	Ger-mina-tion %	Total weed content and predominant weeds	Remark
08/11	*Poa alpina*	107	Saltfjellet	Fidja II	2009	53	21 June	Combiner	460	99.1	367	75	Total: 0.44%. *Poa annua, Avenella flexuosa, Festuca ovina*	OK
08/54	*Poa alpina*	108	Vinje	Låvekroken	2010	148	21 June	Combiner	2115	78.6	397	84	Total: 0.24%. *Alopecurus geniculatus, Avenella flexuosa, Festuca ovina, Poa annua*	OK
08/15	*Festuca rubra*	109	Saltfjellet	Låvekroken	2010	17	25 July	Combiner	1035	96.5	1009	91	Total: 0.09%. *Cerastium arvense, Carex saxatilis, Rumex acetocella*	OK
		110					3 Aug.	Combiner	175	93.4	947	88	Total: 0.43%. *Cerastium arvense, Poa annua, Phleum pratense, A. geniculatus*	OK
05/13	*Luzula frigida*	116	Vetlefjell, Voss	Fidja III	2006/ 2008	30	26 June	By hand	145	69.2	286	83	Total: 29.6%. *Rumex acetocella*	Discard
08/129	*Luzula frigida*	117	Valdresflya	Låvekroken	2010	18	26 June	By hand	275	96.6	423	65	Total: 0.02%. *Matricaria matricariodes*	OK
08/124	*Luzula frigida*	118	Stryne-fjellet	Fidja II	2009	14	26 June	By hand	125	99.9	421	90	No weeds	OK
08/137	*Carex brunnescens*	121	Stryne-fjellet	Fidja II	2009	175	6 July	By hand	376	96.3	432	66	Total: 0.58% *Poa annua, Poa trivalis*	OK
		119					11 July	Combiner	107	98.7	413	80	Total: 0.30%. *Poa trivialis, Avenella flexuosa*	OK
		120					13 July	Combiner	35	90.9	359	60	Total 0.64% *Poa trivialis*, *Cerastium arvense*	OK

Table 17. continued

Collect-ion no	Species	Lab. no	Collection site	Multipli-cation field, Landivk	Year of estab-lish-ment	Area of seed field m2	Seed harvest date	Seed harvest method	Seed yield, grams	% purity	Thousand seed weight mg	Ger-mina-tion %	Total weed content and predominant weeds	Remark
08/150	*Avenella flexuosa*	122	Bykle	Klumprot-teigen	2009	50	16 July	Combiner	326	94.8	463	41	Total: 0,04% *Poa annua, Festuca ovina*	OK
		123				30	16 July	Combiner	144	96.6	595	56	Total: 2.5% *F. ovina*	Use as is
		101				80	18 July	Combiner	91	83.4	729	62	Total: 3.3% *Poa annua, Festuca ovina, Poa pratensis*	Use as is
08/145	*Avenella flexuosa*	124	Stranda	Fidja II	2009	53	13 July	Combiner	2480	97.1	572	75	Total: 0.5%. *F. rubra*	OK
		125					18 July	Combiner	77	47.8	493	62	Total: 19.3% *Poa annua* 18.2%	Discard
05/39	*Avenella flexuosa*	126	Sør Fron	Låvekroken	2010	86	16 July	Combiner	8380	97,1	495	69	Total: 0.3%. *Cerastium arvense, Festuca ovina, Poa annua*	OK
		127					18 July	Combiner	425	76,2	508	61	Total: 2.6%. *P. annua, R. acetocella, Festuca ovina, A. genculatus, Cerastium arvense, Phleum pratense, Trifolium repens*	Use as is
07/20	*Avenella flexuosa*	128	Norefjell	Fidja III	2008	70	16 July	Combiner	1944	92,4	535	41	Total: 1.16%: *Festuca ovina, R. acetocella*	Use as is

Table 18. Seed harvested in second generation commercial seed crops in 2012.

Collection no.	Species	Collection site	Lab. no	Seed grower	Establishment year	Seeded area, ha	Harvested acreage, ha	Cleaned seed yield, kg	% Clean-out	% purity	% weed content	Thousand seed weight mg	Speed of germination %	Germination capacity, %	Total weed content and weeds identified
07/1	*Agrostis capillaris*	Vrådal	9	Jon Sæland	2009	0.32	0.32	101.0	43	98.6	0	82	95	95	Traces of *Poa trivialis*
05/1	*Agrostis mertensii*	Voss	3	Hans Ole S. Erikstein	2010	0.5	0.4	20.0	75	95.8	2.65	112	81	88	*Poa trivialis*: 1.03 %, *Alopecurus geniculatus:* 0.84%, *Poa annua*: 0.23%,*Cerastium arvense*: 0.23% *Capsella bursa-pastoris*: 0,16%
08/41	*Agrostis mertensii*	Stryne-fjellet	1	Tronn Kløcker	2011	0.5	0.5	62.5	32	97.1	1.27	144	79	93	*Poa annua*: 0.95%, *A. geniculatus*: 0.32% (First combining)
			2					64.0	48	93.3	0.60	127	67	88	*Poa annua*: 0,32%, *A.geniculatus*: 0,20%, *Phleum pratense*: 0.05%, *Matricaria matricarioides*: 0,03%
			17					4.5	-	97.9	0.55	128	79		Trial border plots. *M. matricarioides*: 0.19%, *Poa annua*; 0.36 %. Germination period not finished, 12 April 2013
			15					8.2	-	95.5	0.40	125	41	88	Seed from trial. *M. matricarioides*: 0.18%, *Poa annua.*: 0.09 %, *Leontodon autumninalis*: 0.13%
05/L9	*Poa alpina*	Kvikne, Tynset	7	Olav Midtbø	-	1.5	1.0	763.0	31	96.9	0.03	466	93	94	Total: 0.03% *Viola arvensis*
05/L9	*Poa alpina*	Kvikne, Tynset	13	Nils Olav Bjerva	2010	0.6	0.6	804.0	12	92.6	0.94	461	78	92	*Alopecurus geniculatus*: 0.54%, *Poa trivialis*: 0.32%, Agrostis capillaris: 0.08%
08/56	*Poa alpina*	Bykle	11	Jon Midtbø		1.0	1.0	39.5	59	89.6	1.15	390	56	68	*Poa annua:* 0.75% *Alopecurus geniculatus* 0,25%
05/18	*Poa alpina*	Vika-fjellet	16	Jon Sæland	2008, 2010	1.0	1.0	794.0	24	98.4	0.15	455	49	91	*Alopecurus geniculatus*: 0.05%, traces of *Poa annua*

Table 18 continued

Collection no.	Species	Collection site	Lab. no	Seed grower	Establishment year	Seeded area, ha	Harvested acreage, ha	Cleaned seed yield, kg	% Clean-out	% purity	% weed content	Thousand seed weight mg	Speed of germination %	Germination capacity, %	Total weed content and weeds identified
05/32+ 05/73	Phleum aplinum	Ulvik	12	Jon Sæland	2009 + 2010 + 2011	1.3	1.1	285.5	43	99.2	0.67	397	86	95	*P. trivialis*: 0.41%, *P. annua*: 0.15%, *A. geniculatus*: 0.09%, *Capsella bursa-pastoris*: 0.02%
07/01	Phleum alpinum	Haukeli	10	Tronn Kløcker	2011	1.0	0.9	62.0	66	94.9	4.20	402	94	98	Total: 4.20%. P. annua: 3.8%, A. geniculatus: 0.20 %, P. trivialis: 0.17%,
05/17	*Phleum alpinum*	Vika-fjellet		Arne Svalastog	2011	1.07	1.07	Ca 600							Main lot under cleaning, 12 April 2013
								7.4	56	98.3	1.17	352	-	93	Trial seed: *Poa annua*: 0.62%, *Nasturtium officinale*: 0.30%
05/L7	*Festuca ovina*	Kvikne, Tynset		Neri Hestetun	2010	0.5	0.4	88.5	35	96.8	0.25	441	47	83	*Poa pratensis*: 0.06%, *Festuca rubra* 0.06%, *Poa trivialis*:0.04%, *Poa annua*: 0.02%, *Alopecurus geniculatus*: 0.02%
05/41	*Festuca ovina*	Sør-Fron	14	Arne Svalastog	2010 and 2011	1.55	1.55	924	27	97.2	2.15	385	42	79	*Poa trivialis:* 0.71%, *P. annua*: 0.69%, *F. rubra*: 0.43%, *A.geniculatus:* 0.32 %
05/55+ 56	*Festuca ovina*	Hol		Jon Sæland	2009	2.80	2.80	Ca 500							Not cleaned by 12 April 2013
08/145	*Avenella flexuosa*	Stranda	4	Hans Ole S. Erikstein	2011	0.5	0.35	28.0	60	95.1	3.44	666	51	88	*Alopecurus geniculatus*: 1.88%, *P. pratensis*: 0.96%, *Poa annua* 0.55%, *Viola arvensis* 0.05%
05/39	*Avenella flexuosa*	Sør-Fron	5	Jon Sæland	2008 + 2009	0.1	0.05	13.0	69	85.0	13.47	617	37	84	*Festuca ovina:* 7.4%, *A. geniculatus*: 2.6%, *Carex leporina* 1.2%, *Poa pratensis*: 1.1%, *P. trivialis*: 0.7%
08/150	*Avenella flexuosa*	Bykle	6	Håkon Holtar	2011	0.4	0.3	22.0	60	66.0	31.07	688	24	65	*Poa pratensis*: 14.47%, *Festuca ovina:* 14.36%, *Poa annua*: 1.25%, *Alopecurus geniculatus*: 0.75%
Total								**Ca 5200**							

WP 4. Local adaptations and key traits for seedling establishment

Hans Martin Hanslin and Knut Anders Hovstad

First experiment on allocation strategies under optimal conditions

Twenty to thirty per cent of the root scans remain before we can start to analyse the whole dataset. The method is time consuming but works well. A manuscript will be prepared during spring and submit before summer. The working title is: "Different strategies in a critical phase: Comparisons of early root development and growth of graminoid seedlings".

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Recent improvements in analyses of plant growth and plant allocation strategies (e.g. Paine et al 2012, MEE 3, 245–256), Poorter & Sack 2012, Frontiers in plant science doi: 10.3389/fpls.2012.00259), will greatly improve the output from our first two experiments. However, results have to be implemented and run in R, a shift in statistical software that requires some patience.

Fig. 23. Seedlings were grown in these columns before harvest, scanning, drying and weighing.

Experiment on seedling dehydration avoidance and relative drought resistance among graminoid species

An experiment was run during summer 2012 where we recorded seedling survival under drought and used additional harvest to relate survival to root growth plasticity under drought, leaf relative water content, allocation patterns and size. Here we used 40 cm soil columns in a greenhouse compartment (Fig. 23). Also in this experiment, some root scans remain before we can start to analyse data. Preliminary results show interesting patterns, with some of the narrow-leaved grasses having more

similar responses than expected. A manuscript based on the results from this experiment will be completed the second half of 2013.

As most other stress responses, responses to drought is size or stage dependent. In this experiment we used plants of even age. The next step is to test plants of even size.

Fig. 24. In the drought experiment we used these columns filled with a sandy soil

Production of seeds for local adaptation study

All sampled material from 2011 was taken from cold storage (vernalization) and placed in small pollination chambers in a greenhouse compartment at beginning flowering. A simple system with overpressure continuously directing fresh air from outside to each chamber was used. This gave a reasonable temperature control at about ambient air temperature and air movement for pollination. Unfortunately, the plants experienced outdoor temperatures of 30-31 °C for some subsequent days during flowering and seed set in most populations was low and the quality not sufficient. Seed production was well outside the flowering period of *F. ovina* in the surrounding vegetation with no risk of contamination from lowland populations. After seed collection, plants were grown outdoors until October/November, when they were hardened at +2°C and a 6 hour day length for 3 weeks before cold storage. We will make a new attempt to produce seed this winter (starting mid February 2013).

Local adaptation and genetic differentiation

We had to decide on design and locations for the local adaptation study. As we wanted to include the humidity gradient found east-west in Norway, we made a last attempt to find *Festuca ovina* plants near Åndalsnes. We found some flowering material, within a stand of viviparous *Festuca*, but the identity is uncertain and there were too few plants to include in the seed production. The flexibility of flowering and vivipary in both F. ovina and F. vivipara has long been recognized (e.g. Heide 1988), Oikos 5: 171-178), but the *F. ovina-vivipara* complex may be a more dynamic system than appreciated and a recent study state that *F. vivipara* is morphologically and ecologically, but not genetically distinct from F. ovina (Chiurugwi et al 2011, Heredity 106, 854–861). We ended up with a design based on the more eastern populations already sampled. We visited these locations and discussed different designs and how to take care of the small-scale variation in ecological conditions like humidity and vegetation composition. We also consider the option to lay out a common garden experiment close to the experimental site of WP5 at Hjerkin.

WP 5: From seeds to vegetation

Dagmar Hagen (NINA), Knut Rydgren (Høgskolen i Sogn og Fjordane), Line Rosef (UMB) and Bård Pedersen (NINA)
International partner: Ása L. Aradóttir, Agricultural University of Iceland.

Aim and approach

WP 5 addresses the following subgoal of ECONADA:

- To clarify the impact of ecological factors on seed establishment after various types of disturbances and to determine when sowing is appropriate and the implications of sowing for long term vegetation development.

In WP 5 we study the ecological possibilities and constraints of using native seeds in restoration projects by two main approaches: 1. Short-term establishment experiment, and 2. Long-term vegetation dynamics. This is studied by data from a new and one existing experiment site and from vegetation analysis in old seeded sites (Figure 25).

The main activities in 2012 have been data sampling in the main experimental site at Hjerkinn, Dovrefjell and preparation and analysis on data from old seeded heaps in Hemsedal, Hol, and Aurland. Below we will present the status and activities in 2012 for all parts of WP5.

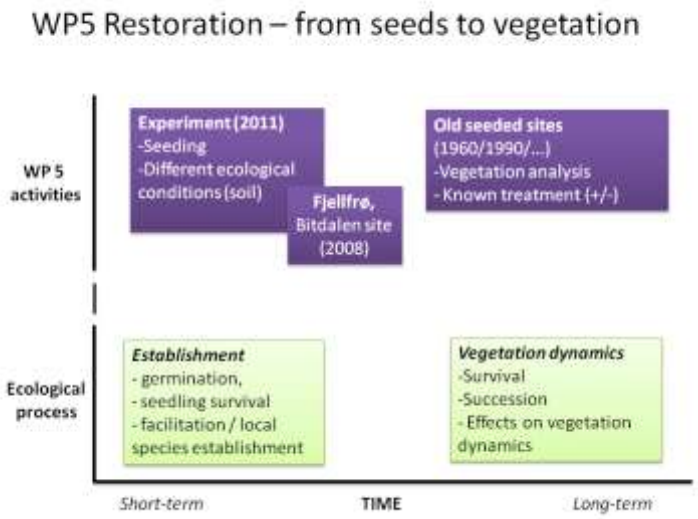

Fig. 25. A conceptual description of ecological processes and activities to study short term and long term results after seeding in alpine disturbed sites.

Experimental site at Dovrefjell (Experiment 2011)

The main experimental field site in WP 5 was established at Hjerkinn, Dovrefjell (1000 meters above sea level) in 2011. In a randomized single quadrate design we included four soil treatments (coarse mineral soil, fine mineral soil, organic peat, and organic topsoil) and five seeding treatments (*Festuca ovina*, *Poa alpina*, *Luzula multiflora* ssp. *frigida*, a mix of all three species, and no seeding). The set-up was replicated eight times, making up a total of 160 permanent plots (0.5 x 0.5 m2). Hjerkinn-PRO (Norwegian Defence Estate Agency) and Fjellfrø (Bioforsk) supplied the seeds and crew from Hjerkinn PRO provided local soil for the experiment (Figur 26).

Fig. 26. Seeds and soil in the experimental site at Hjerkinn, Dovre, established in August 2011.

Germination could be observed late autumn 2011 and during spring 2012. The site was visited during spring and early summer for remarking of permanent plots and for observing if animals had done any damage. We had some small musk-ox problems as animals tramped in some plots, but the damage was limited and caused no problems for the experiment.

Soil from the four soil types in the experiment have been analyzed at the IPM-laboratory (UMB) for pH, dry matter, loss on ignition, total C, total N, H+, Ca2+, K+, Mg2+, Na+.

The first total data sampling at the site was done in August 2012 (Fig. 27). A total of six persons were involved in the analyses. Two English exchange students from AMBIOS volunteers program were part of the field team.

- Seedling establishment (germination) of all species (vascular plants, lichens, bryophytes) was recorded in all permanent plots, including both seeded species and native species. Quadrates with 64 subplots were used to record seedling establishment and further to calculate frequency (Fig. 28).
- We recorded percentage plant cover in all plots (for seeded species separately and total cover) and gave each plot a vitality score for how vigorous and green the cover was (1 = poor vitality, 2 = good, 3 = very good) (Fig. 26).
- In each plot three plant individuals were picked systematically and the height was measured in mm. This height measure is an additional vitality parameter (Fig. 27).
- Pictures were taken of all plots.

Fig. 27. Kathryn and Ingvild doing field work at Hjerkinn, Dovrefjell, recording frequency (left) and plant height (right) in permanent plots.

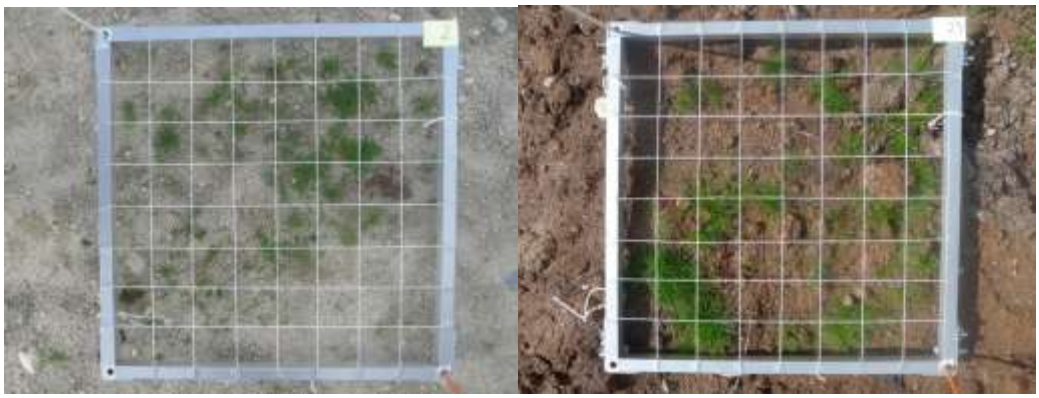

Fig. 28. Illustration of permanent plots divided in 64 subplots for recording species frequency in fine mineral soil (left) and organic peat (right). Both these plots had vitality 3.

Experimental site at Bitdalen (Experiment 2008)

Field site Bitdalen (940 metres above sea level) was established in 2008 with three different soil types (mineral soil, organic soil and a mixture of these two (mixed)) and three seeding treatments (a local seed mixture (Fjellfrø), a commercial seed mixture and no seeding) (Fig. 29). The set-up was replicated three times. Seed establishment and recovery have been recorded from 2008 until 2010 as part of the project FJELLFRØ. In 2011 vegetation analyses were done within ECONADA WP5. We did not do any recording of this field during 2012. We assumed that the greatest change in cover and species composition would be during the first years (2008-2011). Therefore we will do the recordings every second year, and next recording will be in 2013.

Fig. 29. The field site at Bitdalen in 2011. The areas with almost no vegetation are the mineral soil plots. The plots with most vegetation (*Agrostis capillaris*) are the plots with no seeding.

Spoil heaps (old seeded sites)

In 2011 we collected data on vegetation variation (vascular plants, bryophytes and lichens) and environmental factors from five spoil heaps situated in Hemsedal, Hol, and Aurland (Fig. 30). The two oldest spoil heaps are unseeded, while the others have been seeded.

Fig. 30. Field work in July 2011 at Låvisdalen spoil heap, Aurland and Stuv, Hol.

Since last year determination of specimens of bryophytes and lichens has been done and all data sets (species composition and environmental data) are ready for analysis. In the first preliminary DCA ordination the two un-seeded spoil heaps came out differently along the first axis from the other three spoil heaps. Therefore a new DCA analysis was performed with plots only from the three seeded spoil heaps (Fig. 31). This analysis showed that the successional rates proceed much faster on spoil heaps in the lowland, situated around 90 m a.s.l. compared to two other ones that are situated around 800 m a.s.l.

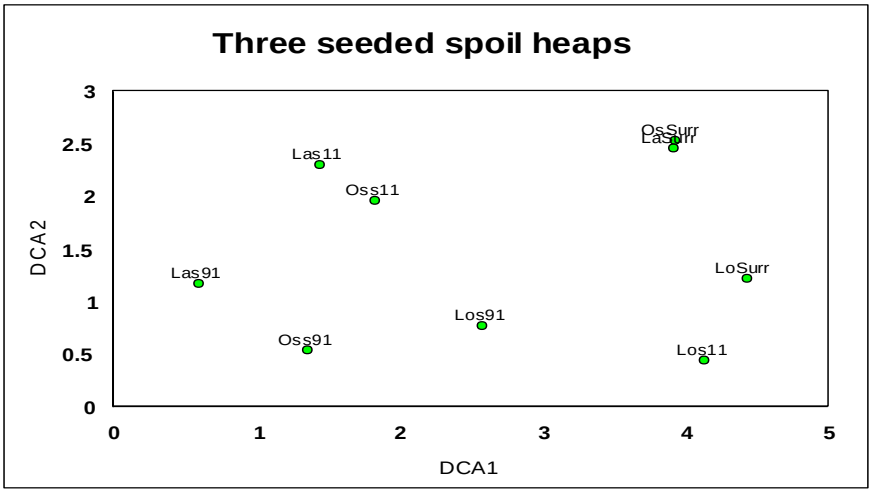

Fig. 31. DCA ordination of plots showing the mean position from three seeded spoil heaps from Aurland at two different times (1991 and 2011) and their undisturbed surroundings. The first two letters gives the locality (La=Låvisdalen; Lo=Loven; Os=Østerbø), the remaining letters and/or numbers gives the year and site (s91=spoil heap 1991; S11=spoil heap 2011; Surr=undisturbed surroundings 2011).

Road margins (old seeded sites)

Vegetation recovery at 20 sites along road margins in Hjerkinn firing range was analyzed during the summer 2010 (Fig. 32). Half of the sites were seeded in 1991 and the rest were untreated. This study was integrated into ECONADA WP5 and the data was a part of a master thesis published in September 2011 (Hansen 2011). The dataset and manuscript have been prepared for scientific publishing, and will be submitted to the Journal Ecological Engineering in short time.

Figur 32. One of the seeded road margins at Hjerkinn after 20 years. The seeded species is still dominating the seeded site and species diversity is highest in the untreated sites.

Meetings, seminars and conferences

Reference group and Consortium board meetings 2012

The reference group and consortium board met in Oslo on 18 January 2012. The reference group had its meeting before lunch and the consortortium board after lunch. See Appendix 1 and 2 for minutes from these meetings.

Meetings in WP leader group

WP leaders had regular contacts by E-mail and telephone, but ther was no meeting in 2012.

8th European Conference on Ecological Restoration

Five of Norwegian scientists and three international experts involved in ECONADA participated at the ECER 2012, 9-14 Sept. in Ceske Budejovice, Chezh Republic (Fig. 33). A total of 328 delgates from 40 countries attended this conference.

Fig. 33. From left to right: Line Rosef, Sandra Malaval, Siri Fjellheim, Dagmar Hagen, Ása L. Aradóttir, Knut Rydgren, Trygve S. Aamlid and Kristin Daugstad outside the conference venue in Ceske Budejovice, Chezh Republic (Armin Bischoff also attended but was not available for photo).

Publications / presentations, 2012

Scientific publications

1. Aamlid, T.S. 2012 Production of site-specific seed for ecological restoration in Norwegian mountain areas. In: Near-natural Restoration. Programme and Abstract book, 8th European Conference on Ecological Restoration, Ceske Budojevice, Czech Republic, September 9-14 2012. p. 24.
2. Fjellheim, S., Elameen, A. & Klemsdal, S. 2012 Ecologically sustainable implementation of the Nature Diversity Act for restoration of disturbed landscapes in Norway – use of molecular markers for defining site specific material. In: Near-natural Restoration. Programme and abstract book, 8th European Conference on Ecological Restoration, Ceske Budojevice, Czech Republic, September 9-14 2012. p. 39.
3. Rydgren, K. Halvorsen, R., Auestad, I. & Hamre, L.N. 2012 Ecological design is more important than compensatory mitigation for successful restoration of alpine spoil heaps. In: Near-natural Restoration. Programme and Abstract book, 8th European Conference on Ecological Restoration, Ceske Budojevice, Czech Republic, September 9-14 2012. p. 68.

Thematic articles, talks/lectures and poster presentations

1. Aamlid, T.S. 2012. Norsk forsking på gras til grøntanlegg og revegetering. Foredrag ved Avslutningsmøte i NFR's program 'Natur og næring', Oslo, 19.april 2012.
2. Aamlid, T.S. 2012 Production of site-specific seed for ecological restoration in Norwegian mountain areas. Oral presentation at The 8th European Conference on Ecological Restoration, Ceske Budojevice September 9-14 2012.
3. Fjellheim, S. 2012. Store og små trusler mot genetisk mangfold i Norsk flora. Populærvitenskapelig foredrag ved Pecha Kucha på Studentersamfunnet under UKA i Ås, 26 oktober 2012.
4. Fjellheim, S. 2012. Ecologically sustainable implementation of the Nature Diversity Act for restoration of disturbed landscapes in Norway – use of molecular markers for defining site specific material. Oral presentation at The 8th European Conference on Ecological Restoration, Ceske Budojevice September 9-14 2012.
5. Hagen, D. og Rydgren, K. 2012. Omvisning i Hjerkinn skytefelt og orientering om Hjerkinn PRO og ECONADA. Ekskursjon for masterstudenter i restaureringsøkologi, Høgskolen i Sogn og Fjordane. 20. september 2012.
6. Hagen, D. 2012. Restoration of nature, including the ongoing research project ECONADA. Feltforelesning og ekskursjon for mastestudentkurs i geografi, Geografisk institutt, NTNU. 21. september 2012.
7. Hagen, D. Restoration of nature, including the ongoing research project ECONADA. Feltforelesning og ekskursjon for ansatte ved det teknisk naturvitenskapelige universitetet i Zurich, ETH. 3. juli 2012.
8. Hagen, D. 2012. Restoration ecology and ecological restoration - and a Norwegian case project. Forelesning ved Institutt for biologi, NTNU. 27. September 2012.

9. Jørgensen, M.H., Hofman, N., Elameen, A., Klemsdal, S. & Fjellheim, S. 2012 How specific is site-specific? Ecologically sustainable implementation of the Nature Diversity Act for restoration of disturbed landscapes in Norway. Poster at PlantBIO, the First National Plant Biology Conference Oslo, 17-18 October 2012
10. Rosef, L. 2012 WP5. Restaurering – fra frø til vegetasjon. Forelesning for masterstudenter i kurset PHG 316, IPM, UMB, oktober 2012.
11. Rosef, L. 2012. Økologisk restaurering etter naturinngrep og ECONADA. Foredrag for miljøgruppa i Statens vegvesen. 8 november 2012.
12. Rydgren, K. 2012. Ecological design is more important than compensatory mitigation for successful restoration of alpine spoil heaps. Oral presentation at The 8th European Conference on Ecological Restoration, Ceske Budojevice September 9-14 2012.
13. Stubhaug, E. & Aamlid, T.S. 2012. Frø til torvtak og revegetering av hyttetomter i fjellet. Stand ved Hyttelivsmessen, Hellerudsletta, 26-28.april 2012.

Project economy (NOK)

COSTS		Budget 2011	Docu-mented costs 2011	Budget January 2012	Revised budget April 2012	Documented costs 2012						Total costs	Budget 2013	Budget 2014	SUM
						Working hours		Person-nal-costs	Other costs (in Norway)	Specification other costs	Int. part-ners				
						Scientist	Techn.								
Bioforsk:															
Activity 19 Ledelse & adm. Aamlid		345000	365468	115000	125000	84	0	91099	2300			93399	325000	290000	1085000
WP1	Activity 191 Innsamling, Aamlid	140000	165339	0	0	0	0	0				0	0	0	140000
WP1	Aktivetet 43 Innsamling, Svanhovd	70000	134700	0	0	0	0	0				0	0	0	70000
WP2	Activity 11 DNA, Klemsdal, Elameen	630000	728331	800000	781250	907	22	890428	71728	Lab. eqipment		962156	280000	10000	1701250
WP3	Activity 31 Frøavl-lok., Daugstad	220000	358138	250000	231250	192	206	401849	62666	On farm trials		464515	280000	355000	1086250
WP3	Activity 192 Frøavl -dyrk.tekn., Aamlid	165000	163860	250000	231250	113	490	458390	16808	On farm trials		475198	300000	375000	1071250
WP4	Activity 15 Hanslin, Hovstad	335000	330669	400000	362500	150	237	302235	27268	Travel etc.	34420	363923	455000	655000	1807500
WP2	UMB - DNA, Fjellheim	220000	114813	485000	466250	344	0	292400		Travel etc.		292400	520000	15000	1221250
WP5	NINA, Hagen, WP5	290000	242544	185000	172500	120	30	148830	39616	Travel etc.		188446	210000	380000	1052500
WP1	NINA, Collection	50000	50000	0	15000				9000	Travel etc.		9000	0	0	65000
WP5	UMB, Rosef	180000	196484	155000	142500	94	95	132150	10350	Travel etc.		142500	170000	220000	712500
WP5	HSF - Rydgren	180000	412064	185000	172500	150	0	135000	38271	Travel etc.		173271	185000	275000	812500
Sum costs		**2825000**	**3262410**	**2825000**	**2700000**	**2154**	**1080**	**2852381**	**278007**		**34420**	**3164808**	**2725000**	**2575000**	**10825000**
FUNDING															
NFR Natur og næring		1375000		1425000	1425000								1150000	1050000	5000000
Direktoratet for naturforvaltning		300000		300000	300000								300000	300000	1200000
NVE		450000		450000	300000								450000	450000	1650000
Statkraft		150000		150000	150000								150000	150000	600000
E-CO Vannkraft		100000		100000	100000								100000	100000	400000
Forsvarsbygg		100000		100000	100000								100000	100000	400000
Jernbaneverket		150000		150000	150000								150000	150000	600000
Statens Vegvesen		100000		150000	150000								200000	150000	600000
Feste landskap				0	25000								25000	25000	75000
Deltakeravgift, seminarer		100000		0	0								100000	100000	300000
Sum funding		**2825000**		**2825000**	**2700000**								**2725000**	**2575000**	**10825000**

Appendix 1: Referat fra møte i referansegruppa for ECONADA

Forskningsparken Blindern
18.januar 2012 klokka 09:30

Til stades: Trygve S. Aamlid, Hans Martin Hanslin, Abdelhameed Elameen og Kristin Daugstad (Bioforsk), Siri Fjellheim og Line Rosef (UMB), Dagmar Hagen (NINA), Line Selvaag (Forsvarsbygg), Astrid Skrindo (SVV), Tone Telnes (Feste landskapsarkitekter), Idunn Kirkreit og Kristin Evjen (NVE), Trine Hess Elgersma (Statkraft), Jon Midtbø (Norsk frøavlerlag), Sigrun Nygård (Jernbaneverket), Astrid Berge (DN).
Opning og velkommen av Trygve. Utgangspunktet var årsrapporten som han hadde sendt til alle involverte, og som han fekk mykje skryt for. Åsa frå Island vart gledeleg overraska, og syntes det var veldig nyttig med ein engelsk rapport for å få vist institusjonen sin kva ho var med på. Sjøl om det ikkje er strengt nødvendig med eit møte er det viktig at me treffast på tvers av arbeidpakkene. Neste møte blir ikkje før i 2013.

Deretter gjekk vi gjennom alle arbeidpakkene ein for ein, og diskuterte om arbeidet gjekk etter planen, økonomi og framtidige planer (det vart kanskje litt knapp tid).

WP1 (Trygve)
For artsvalg, innsamlingsområde og kven som har gjort kva sjå årsrapporten. Det er fortsatt nokon kvite flekkar på kartet, mest pga at arten er sjeldan eller ikkje fins der. Eks. sauesvingel på Vestlandet.
Trine etterlyste innsamling i kystområder for framtidige vindmølle-parkar. Genetisk skiller kyst-populasjonar seg sannsynlegvis lite frå fjell-populasjonar (Siri) men den økologiske tilpassinga er ulik (Astrid S.). Uansett vil ECONADA fokusere på fjell, men vi tar det med til framtidige prosjekt.
Budsjett på 200 000. Reknskapet viser 314 000. Dette mest fordi det vart nødvendig med fleire innsamlarar, og ikkje alle var like økonomiske som NINA som kan kombinere det med andre prosjekt og også har tilgang til ein del studentar.

WP2 (Siri)
Elameen og Nadine jobbar intens, og arbeidet går sin gang (sjå årsrapport)
Problemet er at det manglar artar på mange av lokalitetane og derfor blir det vanskeleg å få til balansert analyse av resultatet. Målet er 10 artar på 20 lokalitetar. Hittil er det berre 3 artar og 8 lokalitetar som er komplette. For eksempel har vi 14 lokalitetar med seterfrytle. Elles er Meråker, Børgefjell, Kvikne og Ringebufjellet dei lokalitetane som manglar flest artar. Kvaliteten på innsamla materiale er forøvrig svært bra.
Siri vil vente med dei statistiske analysene (scoring) til innsamlinga er komplett. Astrid foreslår at vi må få oversikt over kva som er realistisk at vi finn ved ei ny innsamling. Vi veit jo heller ikkje kva som er minimum tal populasjonar per art som må analyserast (det er eit mål for prosjektet å finne ut av).
Dagmar meiner lokalitetane i midt-Norge er realistisk å ta, og sidan NINA er så kostnadseffektive får ho i oppdrag å lage eit budsjett på supplerande innsamling i Meråker, Kvikne og Ringebufjellet. Innsamlinga må gjerast så snart som mogeleg etter snøsmelting.

WP3 (Trygve og Kristin)
Trygve: oppformering, dyrkingsteknikk og kommersialisering

Nær 8 tonn frø av 6 artar er produsert i 2011. Har siste året også prøvd fjellsyre og fjellfølblom. Elles kan nemnast at Bernard Krauzer var med til Telemark på feltinspeksjon til frøavlarane, noko som var svært nyttig. Sjå forøvrig årsrapporten.
Når det gjeld kommersialisering skriv Mattilsynet i sitt brev ' Tillatelse til omsetning av frø av såvare fra prosjekt FJELLFRØ' blant anna: «det forutsettes at bruken av frøblandinger i norsk natur skjer i henhold til naturmangfoldloven». Noko som ikkje hjelper oss spesielt mykje, samtidig som det da blir opp til ECONADA å komme med svaret. Omfanget av frøsalget (kva populasjonar, mengder og til kven) har Trygve best oversikt over, og det beste er å kontakte han når vi, eller andre som kontaktar oss, ønsker frø. Han vil også sende ut ei brosjyre/oversikt over kva som er tilgjengeleg.

Kristin: Lokalisering.
Framdrifta i prosjektet er til å leve med, tatt i betraktning den vanskelege vekstsesongen i Sør-Norge (sjå årsrapport). Ambisjonsnivået har vore høgt, og vi har fått mange interessant resultat, men budsjettet sprakk. Budsjett 220 000. Reknskap 358 000. Dette skuldast først og fremst arbeidet med å bestemme utviklingsstadium på meristem no i haust. Kristin og Trygve går igjennom kva arbeid som må kuttast ned på i 2012. Det blir i alle fall nedgang frå 4 til 3 feltstader, Gvarv går ut. Det kan også hende at vi lar vere å etablere nye felt, dersom vi kan klare oss med dei som vart anlagt i fjor.

WP4 (Hans Martin)
Bakgrunnen er stor dødelegheit hos frøplanter ved etablering i fjellet, spesielt pga tørke. WP4 ser på lokal tilpassing, og i den samanheng er heile planter av sauesvingel i området rundt Dovre samla inn (sjå årsrapport).
Mål for 2012 er blant anna å produsere 1.gen frø til forsøk, velge lokalitetar, og også ønskeleg med genetiske analyser, men det siste krev meir middel/ny søknad til NFR.

Den andre viktige delen av WP4 er å sjå på overleving på frøplantestadiet av fleire aktuelle artar. Dette er fleire artar enn dei 10 i WP1. Det er/blir også supplert med noko låglandsplanter. Hans Martin har til no blant anna sett på rotutvikling, og viste oss imponerande bilder av røter. I 2012 skal WP4 sjå på kva artar og populasjonar som etablerer seg best under tørre forhold. Og kva metoder som kan bedre etableringa, for eksempel mulch, sådjup, gjødsling.

Knut Anders har hittil vore lite involvert, men har stilt opp i kritiske fasar!

WP5 (Dagmar)
Bård Pedersen, Dagmar, Line R, Knut og Åsa er involverte. Arbeidspakka ser både på kortsiktig etablering (nyetablert forsøk på Hjerkinn og eit forsøk i Bitdalen frå 2008) og på langsiktig suksesjon (gamle steintippar både over og under tregrensa). Sjå årsrapporten.

Feltet på Hjerkinn vart etablert etter planen. Det største problemet hittil er sau og moskus. Dei siste kan ikkje gjerdast ute og har rota det til litt på feltet. Om problemet fortsett må det settast inn tiltak. Har hatt arbeidsmøte om kva som skal observerast\registrerast til sommaren.

På feltet i Bitdalen er det gjort registreringar i 2012. Det er kan hende ikkje nødvendig å registrere der kvart år i framtida. Etter 3 år er det like god dekning på sådde og ikkje sådde ruter. Raigraset er dødt medan raudsvingelen held stand, men den set ikkje frøstenglar fordi den er for tett.

Når det gjeld gamle steintippar er det gjort grundige analyser i 2012, og resultata er i ferd med å bli berekna og publisert (Knut m.fl.). Det er også fleire masteroppgåver som er utgitt eller i ferd med å bli utgitt som kan knyttast til WP5, blant anna ei oppgåve om vegkantar tilsådde i 1990. Her viser resultata at det etter 20 år er best dekning men færrast artar på dei sådde rutene, og artane er stort sett dei same som dei som vart sådde. På usådde ruter er det dårlegare dekning men fleire artar.

Masteroppgåvene er:
Tor Ivar Hansen. 2011. Long-term effects of seeding in an alpine environment. IBI - NTNU.
Ellen Torsæter Hoff. 2012. The effect of restoration treatments on the regeneration pathway in alpine seed plants. IBI-NTNU.
Melle. UMB. (kontakt Line R. for fullstendig referanse her).

Plan for 2012 er kan hende å ta inn fleire eldre felt, for eksempel vegkantane i Oslofjord-tunnel-utbygginga. Jon Midtbø etterspurte fleire i fjellområde, og Trine og Trygve hadde fleire forslag, blant anna Vikafjell-feltet. Dette blir diskutert og vurdert!

Evaluering av seminaret i Flåm
Inntektene frå seminaret dekte kostnadene til dei utanlandske foredragshaldarane. Det var ca 40 deltakarar, og Trygve hadde ønska seg fleire. Muligens kolliderte seminaret med andre møter/seminar, men dette er svært vanskeleg å planlegge. Ein fordel med eit «lite» seminar er at det gjer feltekskursjonen enklare å handtere. Blir arrangementet større må det tenkast nytt her.

For framtidige seminar (første i 2013) diskuterte vi om innhaldet må leggast opp/spissast etter målgruppe. For eksempel eit praktisk retta nasjonalt seminar og eit vitskapeleg internasjonalt seminar. Eventuelt kan vi bruke ei heil veke på å først ha eit nasjonalt og så eit internasjonalt seminar på same staden.
Rekkefølga på desse og lokalisering vart diskutert.
Forslag stad: Hjerkinn er udiskutabelt men også Lofast og Bitdalen vart nemnt. Det er berre å komme med fleire gode forslag!!

Markedsføring av ECONADA, internt og eksternt
Trygve minna om at alle må markedsføre prosjektet i eigen organisasjon.
Tone etterlyste ein powerpoint-presentasjon eller lignende. Posteren som vart vist på Island på ReNo-konferansa kan vere egna! Relativt fort gjort å skrive den om til norsk også.

Internasjonale møter og konferanser
Dagmar informerte om følgande :

I Tsjekkia går den 8. europeiske konferansen i økologisk restaurering av stabelen, 9.- 14. september. Sjå meir informasjon på www.ecer2012.eu . Frist for abstract er sannsynlegvis i april. Her bør ECONADA stille med ein delegasjon !

I Ohio, USA, er det frå 30.sept til 5.okt ECOSUMMIT Internasjonal kongress om økologisk restaurering http://www.ecosummit2012.org. Men det er kanskje like greit å utsetje Amerika-turen til 2013 då Society for Ecological Restoration International (SER) har jubilieumskonferanse ?

ReNo er slutt, men det er søkt om vidareføring, noko som er avhengig av deltakarar frå Skottland og Canada.

Kostnadsbudsjett og betalingsrutiner 2012

Trygve minna om at Bioforsk liker best å få rekning kvart tertial, så vi ser helst at det skjer. Men det er ikkje eit absolutt krav.
Og det Bioforsk vil ha inn, fakturerer vi første halvår. Hugs riktig bestillingsnr\prosjektnr eller lignende!!!! (Står på kontrakten).

Avslutta møtet med felles lunsj saman med styringsgruppa, som skulle ha møte etter lunsj.

Heggenes 13.februar
Kristin Daugstad (ref.)

Appendix 2 Referat fra møte i Styringsgruppa for prosjekt ECONADA

Sted: Norsk institutt for naturforsking (NINA), Forskingsparken i Oslo
Tid: Onsdag 18.januar kl 13.00 -15.15.
Til stede: Ingvar Hage, Bioforsk (prosjektansvarlig)
Inga Bruteig, NINA (i stedet for Signe Nybø, representerte også Høgskolen i Sogndal)
Øystein Johnsen, UMB
Erland Røsten, Statens Vegvesen (i stedet for Sidsel Kalås, til kl. 14:15; representerte også Forsvarsbygg og Jernbaneverket)
Trine Elgersma, Statkraft
Idunn Kirkreit, NVE (i stedet for Haavard Østhagen)
Kristin Evjen, NVE
Jon Midtbø, Norsk frøavlerlag
Tone Telnes, Feste landskapsarkitekter
Siri Fjellheim, UMB (til kl 14.00; leder for ECONADA-WP 2)
Dagmar Hagen, NINA (leder for ECONADA-WP 5)
Hans Martin Hanslin, Bioforsk (leder for ECONADA-WP 4)
Trygve S. Aamlid, Bioforsk (prosjektleder for ECONADA, leder for WP 1 og sekretær for styringsgruppa)

Forfall: Gunn Paulsen, Direktoratet for naturforvaltning

Sak 1. Konstituering og presentasjonsrunde
Styringsgruppa konstituerte seg med Ingvar Hage som leder.

Sak 2. Opptak av nye deltakere i konsortiet
Feste landskapsarkitekter og Norsk frøavlerlag ble opptatt i konsortiet ved akklamasjon. Det forutsettes at de nye partene slutter seg til konsortieavtalen, ogTrygve S. Aamlid vil ta initiativ slik at de nødvendige underskrifter kommer på plass. Framtidig representasjon av Feste landskapsarkitekter og Norsk frøavlerlag i styringsgruppa avklares mellom henholdsvis Tone Telnes og Jon Midtbø og Ingvar Hage/Trygve S. Aamlid.

Sak 3. Generelt om prosjektorganisering i Bioforsk og styringsgruppas rolle
Ingvar Hage orienterte.

Sak 4. ECONADA: Bakgrunn, søknadshistorikk og faglig status pr. 1.jan. 2012.
Trygve S. Aamlid, Siri Fjellheim, Hans Martin Hanslin og Dagmar Hagen orienterte med utgangpunkt i Bioforsk rapport 7(4), som var utsendt på forhånd. Styringsgruppa tok orienteringen til etterretning og mente prosjektet hadde fått en god start.

Sak 5. Økonomisk gjennomgang. Godkjenning av økonomirapport til Norges forskingsråd
Trygve S. Aamlid gjorde rede for inntekter og kostnader for prosjektet totalt og de ulike arbeidspakker. Totalfordelingen mellom de deltagende FoU institusjoner var nevnt i søknaden til NFR, og WP-ledere hadde i mars 2011 blitt enige om hvordan midlene skulle fordeles utover i prosjektperioden. Fordi innsamlingsarbeidet i WP1 var blitt dyrere enn forutsatt, hadde det i løpet av året vært nødvendig å gjøre noen små justeringer.

Regnskapene for de ulike arbeidspakker for 2011 viste at noen gikk med underskudd, mens andre gikk med overskudd. Ut fra de ulike FoU deltakernes timesatser viste rapporten til NFR at den totalt ressursbruken i prosjektet i 2011 utgjorte kr 3.262.410, som er kr 438.957 mer enn finansieringen fra NFR og brukerne i prosjektet.
Styringsgruppas medlemmer tok regnskapet til etterretning og understreket at det er forskernes ansvar å planlegge slik at de ulike arbeidspakker totalt sett går i balanse over prosjektperioden. Representantene fra NINA, UMB og Bioforsk mente at det har liten betydning om det er underskudd enkelte år og overskudd i andre år så lenge dette jamner seg ut over prosjektperioden.
Den økonomiske rapporten til NFR ble godkjent og underskrevet av styringsgruppas leder Ingvar Hage.

Sak 6. Møteplan for Styringsgruppa
Ingvar Hage mente at det neppe var behov for årlige møter i Styringsgruppa, men at gruppa må kunne sammenkalles ved behov. E-post korrespondanse vil ofte være tilstrekkelig, og videokonferanser kan også benyttes. Dette fikk allmen tilslutning.

Sak 7. Eventuelt
To saker ble nevnt:

a) Ingvar Hage fortalte at NFRs program 'Natur og næring', som finansierer ECONADA, fra 1.jan.2012 er slått sammen med 'Matprogrammet' det nye programmet 'Bionær'. I den forbindelse er det tillyst et avslutningsseminar for å markere hvilke forskingmessige framskritt som 'Matprogrammet' har bidratt til. Det forventes et tilsvarende avslutningsseminar for 'Natur og næring'. Her bør ECONADA være med og melde på et innlegg.

b) Inga Bruteig understreket formidlingsdelen av ECONADA. Ifølge opplysninger på NRK Radio (P2) er bare 20% av norske forskere opptatt av å formidle sine resultater til allmenheten. ECONADA forventes å gi mye ny kunnskap, og det er viktig at dette blir formidlet, også populærvitenskapelig.

Bioforsk Landvik, 24.januar 2011. Trygve S. Aamlid (referent)