Date: 2022-12-07	*Version:* 2	*Authors:* H. Boehner, K. A. Bråthen, E. Soininen

Plant measurements in experimental setup of snow beds

Motivation

The plant communities of snow beds are influenced by deposition of snow to such a degree that it much overrules other factors. Thus, these plant communities are likely to be sensitive to climate change driven alterations of snow cover. Snow beds are also important habitats of small rodents, especially lemmings, and important summer feeding habitats of reindeer. Thus, the trajectories of change in snow beds will be modified by herbivory.

State variables:
Plant measurements in snowbeds are used for the following state variables:

- V15; Plant species abundance and community composition: snow beds
- V23; Norwegian lemming winter grazing impact and moss regrowth in snow beds

Reference to method:
Plant abundance is estimated using point intercept frequency (Bråthen & Hagberg 2004, Jonasson 1988). Plant groups are based on functional units (Bråthen et al. 2007, Ravolainen et al. 2013).

Spatial study design

The herbivore exclosure experiment is conducted in the intensive study design at Varanger, at 16 snowbed sites in Vestre Jakobselv and 16 snowbed sites in Komagdalen. At both localities, the sites are grouped to two altitudinal transects (sections Torvhaugdalen and Tranemyra forming one transect in Vestre Jakobselv, whereas Bearalveaijohka and Gåsevannan form the other transect). Majority of the sites in Vestre Jakobselv are in the sections Torvhaugdalen and Bearalveaijohka, and the additional sites were added partly to logistic reason (i.e. large enough vegetated patches where exclosures could be established) and partly to extend the altitudinal transect. The sites in Komagdalen are in the sections Kjøltindan and Ruossachokka.

The complete list of siteIDs included in the current data collection is:

Locality	Section	Site_ID snowbed (sn)
Vestre Jakobselv (vj)	Torvhaugdalen (to)	vj_to_sn_3, vj_to_sn_6, vj_to_sn_13, vj_to_sn_14, vj_to_sn_20, vj_to_sn_22, vj_to_sn_25
Vestre Jakobselv (vj)	Tranemyra (tr)	vj_tr_sn_2
Vestre Jakobselv (vj)	Bearaveaijohka (be)	vj_be_sn_1, vj_be_sn_8, vj_be_sn_12, vj_be_sn_13, vj_be_sn_14, vj_be_sn_17, vj_be_sn_22
Vestre Jakobselv (vj)	Gåsevannan (ga)	vj_ga_sn_2
Komagdalen (ko)	Ruossachokka (ru)	ko_ru_sn_1, ko_ru_sn_5, ko_ru_sn_19, ko_ru_sn_8, ko_ru_sn_10, ko_ru_sn_13, ko_ru_sn_14, ko_ru_sn_16

Komagdalen (ko)	Kjøltindan (kj)	ko_kj_sn_2, ko_kj_sn_5, ko_kj_sn_7, ko_kj_sn_14, ko_kj_sn_17, ko_kj_sn_18, ko_kj_sn_13, ko_kj_sn_10

These sites are in the GPS-files “snowbeds lemming transect 2019.gpx” and “small mammal cameras 2019.gpx” https://uitno.app.box.com/file/354916477175 and https://uitno.app.box.com/file/356643069925

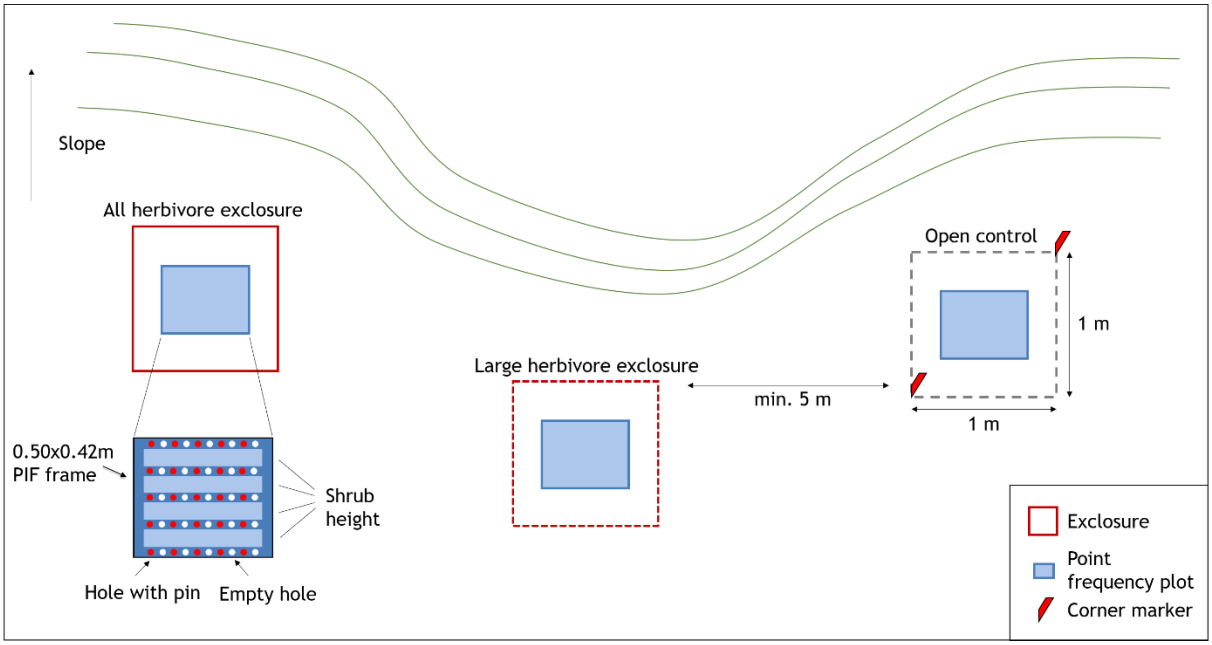


Figure 1: Study design within a site with an all herbivore exclosure, a large herbivore exclosure and an open control. Point frequency plots are placed in the middle of the exclosures or the control facing towards the slope.

Each site has three plots for point intercept frequency with different treatments. The distance between the plots is at least 5 m (Figure 1). Plant measurements are conducted in a 50x42 cm plot which is placed in the middle of the exclosures and the control area.

Treatment descriptions:

- **All herbivore exclosures:** All mammal herbivores are excluded by 1x1x0.5 m cages with chickenwire with a mesh size of 1.3 cm and a flap which is attached to the ground around the cage to prevent rodents from digging into the cage (Figure 2)
- **Large herbivore exclosures:** Larger mammalian herbivores such as reindeers are excluded by 1x1x0.5 m cages. The cages have a wire in the middle of the cage sides and a top with netting with mesh 10 cm.
- **Open control:** A 1x1 m area for control measurements is marked with two tent plugs in opposite corners.

The plots were established accordingly: we first selected 3 (or more) patches of similar vegetation, with at least 5m in between. We then assigned the treatment randomly. Thereafter we assessed whether some of them would not be suitable for exclosures (eg. large stones, slope) and swopped the treatments because of this.

Temporal study design

All plant measurements are conducted once a year, in early August, during the peak biomass season.

Figure 2: Measuring plant abundance in all herbivore exclosure.

Procedure

A 42x50 cm point intercept frequency frame with 25 pins (one pin in every second hole) is used for measuring plant abundance and shrub height. The frame is placed in the middle of the exclosures and the control area with the longer side of the frame running parallel to the slope of the snowbed. The point frequency frame has to be set straight down without intentionally bending or moving the plants.

Plant abundance: For each pin, the number of times each species is touching the pin is counted and recorded. Point intercepts are in principle registered at species level. However, difficult species are either registered on genus level or are grouped to functional groups. A list of groups (genera,

functional groups) that should be used for difficult species is given in the appendix. An overview of functional groups and those species that should always be registered at species levels is in Table 1.

New species or genera should be only added if it is confirmed that a certain species has been found.

Table 1: Functional groups and species that are recorded separately.

Functional group	Species
Evergreen dwarf shrubs	*Empetrum nigrum, Phylloce caerulea, Vaccinium vitis-idaea*
Deciduous dwarf shrubs	*Alnus incana, Betula pubescens, Betula nana, Vaccinium myrtillus, Vaccinium uliginosum,*
Green willows	
Grey willows	
Prostrate willows	*Salix herbaceae*
Evergreen non woody	*Huperzia selago*
Sedges and rushes	*Carex bigelowii*
Narrow leaved grasses	*Avenella flexuosa, Nardus stricta,*
Broad leaved grasses	*Deschampsia cespitosa, Calamagrostis phragmitoides*
Forbs	*Bistorta vivipara, Chamaepericlymenum suecicum, Rumex acetosa, Trientalis europaea*
Hemiparasites	
Horsetails	
Deciduous vascular cryptogams	

Different types of plant parts are registered separately. The three registered categories are vegetative (leaves), reproductive and woody parts. For forbs, the reproductive part is the flower and the peduncle. The flower is defined as the flower itself and downwards the peduncle until it has branched twice. For species without a branching peduncle, the whole peduncle is considered as reproductive, or down to the first leaf below the whorl. For graminoids, the fertile straw and the flower are recorded as reproductive, all leaves as vegetative. Reproductive structures of a species that are present in the triangle plot but not touching a pin are recorded with the value ‘x’. For woody species, the woody part is defined as the stem (including the green stem of *Vaccinium myrtillus)*.

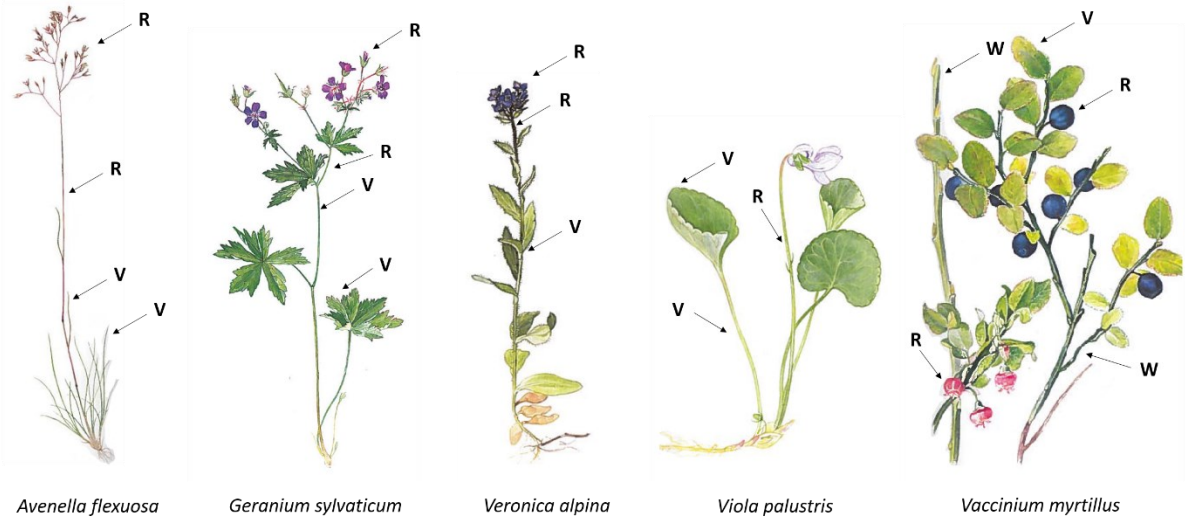


Figure 3: Definition of vegetative, reproductive and woody parts of different plant species.

For species with many small, narrow leaves, like *Selaginella selaginoides*, and *Empetrum hermaphroditum*, number of hits is not counted for each and every leaf touching the pin, but rather per branch.

If the plants reach above the height of the triangle frame, the number of times the plant would touch the pin up to hip height is estimated. If plants enter the plot from the side, having roots outside the plot and touching the pins inside the frame, they are still included in the analyses.

Plant presence: Presence of plant species or genus that do not touch the pin but are found in the plot is denoted with 'x'. Even if some species were registered into functional group for abundance data, their presence should be registered at species level. See Appendix for info on difficult species for which presence can be registered into genera.

In particular, grasses are practical to register into functional groups for abundance data. However, grass species presence in the plot should be recorded.

Ground cover: Ground cover is registered as presence/absence per pin (max 1 hit per pin). The following categories are registered:

- Standing dead parts or litter of vascular plants
- *Dicranum sp.* (hit on *Dicranum,* or moss carpet dominated by *Dicranum* species)
- *Polytrichum sp.* (hit on *Polytrichum* species, or moss carpet moss carpet dominated by *Polytrichum*)
- Moss carpet alive (green, alive looking moss carpet which is not dominated by *Dicranum sp.* or *Polytrichum sp.*)
- Moss carpet dead (brown, dead looking moss carpet)
- Peat mosses (*Sphagnum* sp.)
- Bare soil
- Stone
- Small rodent activity (i.e. where litter is clearly formed by plants chewed by rodents, tunnels and faeces)

Height of thicket forming shrubs: Height of all shrubs, except *Salix herbacea,* within the plots is measured with accuracy to nearest 5 cm. Maximum shrub height is measured in each of the four segments of the point frequency frame. If the thicket is very low and close to the ground shrubs or not present, the value 0 is given. [Make sure 5 cm intervals are marked on at least one of the pins with permanent marker or use a measuring stick]

In addition, check if the exlosures are in good shape or if something should be repaired. If possible, do this, if not possible, let Eeva Soininen know as soon as possible. Note also if there are signs of small rodents inside the all herbivore exclosures. NB the exclosures need to be closed again after recording plants inside them.

Equipment needed

- 50x42 cm point frequency frames with 25 pins. Alternatively at least 5 pins; one can then attach 4 "legs" in the corners and move the 5th pin from hole to hole.
- 2 foldable rulers of 2m each; to locate the middle point of the plots.
- Tablet computer
- Reserve paper field sheets in case of trouble with computer
- Wire, pliers, screws, washers, nuts and zip ties in case exclosures need to be fixed
- Tent pegs and nails in case the control needs remarking
- Flora, notebook and pencil

Information recorded in the field – tablet field form

NB: Data sampling using tablets requires careful data naming and data handling!

Before field work: Field form for snowbeds is available in the COAT Box folder "Protocol/Data sheets for writing data in the field /Point intercept data Varanger". The field forms have to be saved on the tablets before leaving for fieldwork.

At each field site: Fill one field form per treatment. The file needs to be renamed with the site ID, treatment and year (e.g. "vj_to_sn_3_control_2019.xlsx") and saved to right folder.

For each field form: record site-ID, date, name of the person who is registering the point intercepts and comments in the provided fields in the field form. To keep track which plots have been counted, record also site-ID, treatment, date and location of the data (which tablet, folder name or paper field form) in the fieldbook or a separate form. When finished with all pins, make sure that everything is entered correctly, that the file has the correct name and is saved in the correct folder.

For each plot:

- Record number of point intercepts of each species per pin separately for vegetative, reproductive and woody plant parts. Record species and reproductive parts that are present in the plot but not touched by a pin by giving the value 'x'
- Species that are not listed in the field form should be entered in the provided rows (**Additional species**). When entering new species, write the correct scientific names or abbreviations (e.g. emp_nig) as given in the species list in the second sheet of the field form.
- If it is not feasible to record point intercepts on species level (especially for graminoids), register number of point intercepts on functional group level in the provided section in the

field form (**Functional groups**). Species presence should be recorded by giving the value 'x' in addition
- Record ground cover and small rodent activity as presence per pin (max 1 hit per pin) in the provided section in the field form (**Ground cover**)
- Record the shrub height in the provided row in the field form (**Shrub height**). Enter the values in the cells for pin 1, 6, 11 and 16
- **Save the file after each pin**

Every evening: Copy the file to a memory stick as a back-up latest at the end of the day and sign a list with which plots have been done and where the data is stored.

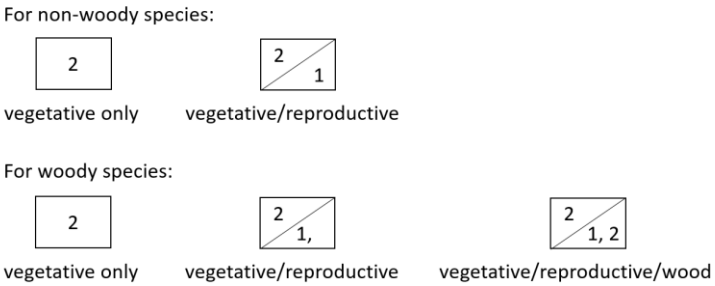
<u>Information recorded in the field – paper field form – as backup to pads</u>

Before field work: Paper field forms are available in the COAT Box folder "Protocol/Data sheets for writing data in the field /Point intercept data Varanger" and should be printed for all sites in case the tablets don't work.

At each field site: Always take enough paper field forms with you!

For each field form and plot, record the same information as when recording data with the tablet field forms.

To separate between vegetative, flowering and woody plant parts, enter data as following:



Every evening: All filled in forms must be verified in terms of correct and reasonable entries (i.e. double check entries with very high numbers of hits) and readable writing. Take a photo of each filled form as a back-up.

<u>Data processing</u>

For data on tablets: Tablets and USB sticks with back up of the data must be delivered to Kari Anne Bråthen, Eeva Soininen, Leif Einar Støvern or Hanna Boehner. In addition, all data files (from tablet and paper field forms) and as well as information about who received the field equipment and where it was placed should be sent to Eeva Soininen.

For data on paper sheets: If data is recorded on paper field sheets, all field observers are in charge of typing their data into digital format (unless otherwise agreed with Eeva Soininen). The data should be entered in the same template as used when recording data with the tablets. The templates are

stored in the COAT Box folder “Protocol/Data sheets for writing data in the field /Point intercept data Varanger”.

Training requirements and specialized skills

Good knowledge of tundra plant species is required for recording point intercept frequency on species level.

New field observers must be trained by experienced observers and the whole field team must ‘calibrate’ at the beginning of the field season to make sure all observers count point intercepts in the same way.

References

Bråthen, K. A., Ims, R. A., Yoccoz, N. G., Fauchald, P., Tveraa, T., & Hausner, V. H. (2007). Induced shift in ecosystem productivity? Extensive scale effects of abundant large herbivores. *Ecosystems*, *10*(5), 773–789. *https://doi.org/10.1007/s10021-007-9058-3*

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Jonasson, S. (1988). Evaluation of the Point Intercept Method for the Estimation of Plant Biomass. *Oikos, 52*(1), 101-106. *doi:10.2307/3565988*

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Appendices

LEGEND
Species that should ALWAYS be analysed on species level (both presence/absence and abundance (PF)).
Species presence/absence should always be recorded. For abundance data (PF), can be group to genus if necessary and if that is not possible, to functional group.
Pre-defined categories that cover several species. Presence/absence mostly on genus level. Can be grouped to functional groups for abundance (PF) if necessary.

Abbreviation	Species or genera	Norwegian_names	PF_functional_group
agr_mer	Agrostis mertensii	fjellkvein	broad_leaved_grasses
agr_sp	Agrostis sp	kvein	broad_leaved_grasses
alc_alp	Alchemilla alpina	fjellmarikåpe	small_forbs
alc_sp	Alchemilla sp	marikåpe	small_forbs
aln_inc	**Alnus incana**	**gråor**	**aln_inc**
alo_pra	Alopecurus pratensis	engrevrumpe	broad_leaved_grasses
and_pol	Andromeda polifolia	kvitlyng	evergreen_dwarf_shrubs
ang_arc	Angelica archangelica	kvann	small_forbs
ant_nip	Anthoxanthum nipponicum	fjellgulaks	broad_leaved_grasses
ant_syl	Anthriscus sylvestris	hundekjeks	tall_forbs
arc_alp	Arctous alpinus	rypebær	deciduous_dwarf_shrubs
ath_sp	Athyrium sp	storburkne	deciduous_vascular_cryptogams
ave_fle	**Avenella flexuosa**	**smyle**	**ave_fle**
bar_alp	Bartsia alpina	svarttopp	hemiparasites
bet_nan	**Betula nana**	**dvergbjørk**	**bet_nan**
bet_pub	**Betula pubescens var pumila**	**fjellbjørk**	**bet_pub**
bis_viv	**Bistorta vivipara**	**harerug**	**bis_viv**
bot_lun	Botrychium lunaria	marinøkkel	deciduous_vascular_cryptogams
cal_lap	Calamagrostis lapponica	finnmarksrørkvein	broad_leaved_grasses
cal_neg	Calamagrostis neglecta	smårørkvein	broad_leaved_grasses
cal_pal	Caltha palustris	bekkeblom	small_forbs
cal_phr	**Calamagrostis phragmitoides**	**skogrørkvein**	**cal_phr**
cal_sp	Calamagrostis sp	rørkvein	broad_leaved_grasses
cam_rot	Campanula rotundifolia	blåklokke	small_forbs
car_aqu	Carex aquatilis agg	nordlandsstarr	sedges_rushes
car_big	**Carex bigelowii**	**stivstarr**	**car_big**
car_bru_can	Carex brunnescens/canescens	seterstarr	sedges_rushes
car_lac	Carex lachenalii	rypestarr	sedges_rushes
car_lim	Carex limosa	dystarr	sedges_rushes
car_liv	Carex livida	blystarr	sedges_rushes
car_nig	Carex nigra	slåttestarr	sedges_rushes
car_pra	Cardamine pratensis agg	engkarse	small_forbs
car_sax	Carex saxatilis	blankstarr	sedges_rushes
car_sp	Carex sp	starr	sedges_rushes
car_vag	Carex vaginata	slirestarr	sedges_rushes

cer_sp	Cerastium sp	arve	small_forbs
cha_ang	Chamerion angustifolium	geitrams	tall_forbs
cha_sue	**Chamaepericlymenum suecicum**	**skrubbær**	**cha_sue**
cir_het	Cirsium heterophyllum	kvitbladtistel	tall_forbs
com_pal	Comarum palustre	myrhatt	small_forbs
des_ces	**Deschampsia cespitosa**	**sølvbunke**	**des_ces**
dip_alp	Diphasiastrum alpinum	fjelljamne	evergreen_non_woody
emp_nig	**Empetrum nigrum**	**krekling**	**emp_nig**
epi_sp	Epilobium sp	mjølke	small_forbs
equ_arv	Equisetum arvense	åkersnelle	equ_sp
equ_pal	Equisetum palustre	myrsnelle	equ_sp
equ_pra	Equisetum pratense	engsnelle	equ_sp
equ_sp	Equisetum sp	sneller	equ_sp
equ_syl	Equisetum sylvaticum	skogsnelle	equ_sp
equ_var	Equisetum variegatum	fjellsnelle	equ_sp
eri_ang	Eriophorum angustifolium	duskull	sedges_rushes
eri_sp	Eriophorum sp	myrull	sedges_rushes
eup_sp	Euphrasia sp	augnetrøst	small_forbs
fes_sp	Festuca sp	svingel	narrow_leaved_grasses
fil_ulm	Filipendula ulmaria	mjødurt	small_forbs
gen_niv	Gentiana nivalis	snøsøte	small_forbs
ger_syl	Geranium sylvaticum	skogstorkenebb	tall_forbs
geu_riv	Geum rivale	enghumleblom	tall_forbs
green_willows	**Green willows**	**grønnbladete_vier**	**green_willows**
grey_willows	**Grey willows**	**gråbladete_vier**	**grey_willows**
gym_dry	Gymnocarpium dryopteris	fugletelg	deciduous_vascular_cryptogams
har_hyp	Harrimanella hypnoides	moselyng	evergreen_dwarf_shrubs
hie_alp	Hieracium alpina agg	fjellsvæver	small_forbs
hie_odo	Hierochloe odorata	vanleg marigras	broad_leaved_grasses
hie_sp	Hieracium sp	svæve	small_forbs
hup_sel	**Huperzia selago**	**lusegras**	**hup_sel**
jun_com	Juniperus communis	einer	evergreen_dwarf_shrubs
jun_fil	Juncus filiformis	trådsiv	sedges_rushes
jun_sp	Juncus sp	siv	sedges_rushes
jun_tri	Juncus trifidus	rabbesiv	sedges_rushes
kal_pro	Kalmia procumbens	greplyng	evergreen_dwarf_shrubs
lin_bor	Linnaea borealis	linnea	small_forbs
luz_mul	Luzula multiflora	engfrytle	sedges_rushes
luz_sp	Luzula sp	frytle	sedges_rushes
luz_spi	Luzula spicata	aksfrytle	sedges_rushes
luz_sud	Luzula sudetica	myrfrytle	sedges_rushes
lyc_sp	Lycopodium sp	kråkefot	evergreen_non_woody
mel_pra	Melampyrum pratense	stormarimjelle	hemiparasites
mel_sp	Melampyrum sp	marimjelle	hemiparasites
mel_syl	Melampyrum sylvaticum	småmarimjelle	hemiparasites

mil_eff	Milium effusum	myskegras	broad_leaved_grasses
min_sp	Minuartia sp	tuvearve	small_forbs
myo_sp	Myosotis sp	minneblom	small_forbs
nar_str	**Nardus stricta**	**finnskjegg**	**nar_str**
oma_nor	Omalotheca norvegica	setergråurt	small_forbs
oma_sup	Omalotheca supina	dverggråurt	small_forbs
ort_sec	Orthilia secunda	nikkevintergrøn	evergreen_non_woody
oxy_dig	Oxyria digyna	fjellsyre	small_forbs
par_pal	Parnassia palustris	jåblom	small_forbs
ped_sp	Pedicularis sp	myrklegg	hemiparasites
phe_con	Phegopteris connectilis	hengjeveng	deciduous_vascular_cryptogams
phl_alp	Phleum alpinum	fjelltimotei	broad_leaved_grasses
phy_cae	**Phyllodoce caerulea**	**blålyng**	**phy_cae**
pin_sp	Pinguicula sp	tettegras	small_forbs
poa_sp	Poa sp	rapp	broad_leaved_grasses
pot_sp	Potentilla sp	mure	small_forbs
pyr_sp	Pyrola sp	vintergrøn	evergreen_non_woody
ran_sp	Ranunculus sp	soleie	small_forbs
rhi_min	Rhinanthus minor	småengkall	hemiparasites
rho_ros	Rhodiola rosea	rosenrot	small_forbs
rub_cha	Rubus chamaemorus	molte	small_forbs
rum_ace	**Rumex acetosa**	**engsyre**	**rum_ace**
rum_acet	Rumex acetosella	småsyre	small_forbs
sag_sp	Sagina sp	småarve	small_forbs
sal_her	**Salix herbaceae**	**musøre**	**sal_her**
sal_sp	Salix sp	dvergvier	prostrate_willows
sau_alp	Saussurea alpina	fjelltistel	small_forbs
sco_aut	Scorzoneroides autumnalis	følblom	small_forbs
sel_sel	Selaginella selaginoides	dvergjamne	evergreen_non_woody
sib_pro	Sibbaldia procumbens	trefingerurt	small_forbs
sol_vir	Solidago virgaurea	gullris	small_forbs
ste_bor	Stellaria borealis	fjellstjerneblom	small_forbs
ste_med	Stellaria media	vassarve	small_forbs
ste_nem	Stellaria nemorum	skogstjerneblom	small_forbs
ste_sp	Stellaria sp	stjerneblom	small_forbs
tar_sp	Taraxacum sp	løvetann	small_forbs
tha_alp	Thalictrum alpinum	fjellfrøstjerne	small_forbs
tri_ces	Trichophorum cespitosum	bjønnskjegg	sedges_rushes
tri_eur	**Trientalis europaea**	**skogstjerne**	**tri_eur**
tri_spi	Trisetum spicatum	svartaks	broad_leaved_grasses
tro_eur	Trollius europaeus	ballblom	tall_forbs
vac_myr	**Vaccinium myrtillus**	**blåbær**	**vac_myr**
vac_uli	**Vaccinium uliginosum**	**blokkebær**	**vac_uli**
vac_vit	**Vaccinium vitis-idaea**	**tyttebær**	**vac_vit**
vah_atr	Vahlodea atropurpurea	rypebunke	broad_leaved_grasses

ver_alp	Veronica alpina	fjellveronica	small_forbs
ver_sp	Veronica sp	veronika	small_forbs
vio_bif	Viola biflora	fjellfiol	small_forbs
vio_sp	Viola sp	fiol	small_forbs