Snowpatch plants and snow: Using functional traits in snowpatch specialists to evaluate growth, regeneration and ecosystem processes

Research question: How does the timing of snowmelt across late-lying snowpatches affect plant functional traits and species interactions at small scales?

Key words: Snowmelt timing, Ecosystem processes, Plant functional traits, Regeneration traits, Competition and facilitation, Herbivore damage, Community composition

Rationale: Environmental filters act to limit the local plant community assemblage from the regional species pool by restricting the viable trait states that can occur there. Across late-lying snow areas in alpine mountains, the timing of snowmelt is a strong filter which can restrict the growth of plants with certain functional traits and lead to changes in community composition across the snowmelt gradient. In coming decades, the strength of this environmental filter is likely to relax with climate warming, and typically late-melting areas may become suitable for species that were previously excluded from them.

We aim to evaluate the effects of snow cover gradients and snowmelt patterns (as indicators of light availability, soil moisture and temperature) at small-scales on plant functional, regeneration, growth and development traits on snowpatch specialists and their close neighbours. In this manner, simple measurements across snowmelt zones can be used to further understand and predict how these highly restricted and important ecosystems will function in a future with less snow. Working at small spatial scales (individual target plant level) also provides an opportunity to understand the mechanisms of change at the scale in which they occur.

We predict earlier snowmelt zones will be more favourable for plant growth and development for generalists than for snowpatch specialists. Earlier snowmelt zones will also contain taller, more competitive species. Late snowmelt zones may contain fewer generalist species but the timing of their phenology is likely more correlated with snowmelt date. This protocol will help to determine how tightly coupled snowpatch species regeneration is linked to snowmelt patterns, whether close neighbouring plants drive any of these patterns and where snowpatch species may persist into the future.

Methods:

General approach:

We choose a snowbed site and a typical snowbed plant species. We identify zones along our snowbed of different snowmelt times (from late to early melt-out). We measure functional plant traits of our target snowbed plant species. We also measure some traits of neighbouring plants and potential competitors and community composition. This protocol should be feasible in one field day.

Choosing a field site:

Choose the snowpatch/snowbed sites that you are familiar with and where you know the general pattern of snowmelt. Divide your snowpatch into at least 3 zones of snowmelt; early melt zone, mid melt zone and late melt zone. Often the vegetation assemblage will be different in each melt zone (Figure 1) but this is not always the case if the snowmelt zones are not very distinct. Ideally, you know the
snowmelt times at your site, e.g. from previous work and temperature loggers. We can also use remote sensing (e.g. PlanetScop, Figure 2) to determine early, mid, late zones for each target snowpatch (Figure 3). The target species for each snowpatch should be common and present across all snowmelt zones.

Figure 1. Distinct snowmelt zones that correspond with vegetation zones are apparent across a snowpatch plant community in the Australian Alps. Darker green shrubs are around the edges in the earlier snowmelt zone, grading into lighter, silvery-green daisies, which then grade into the pale brown graminoids in the centre and late melting zone.

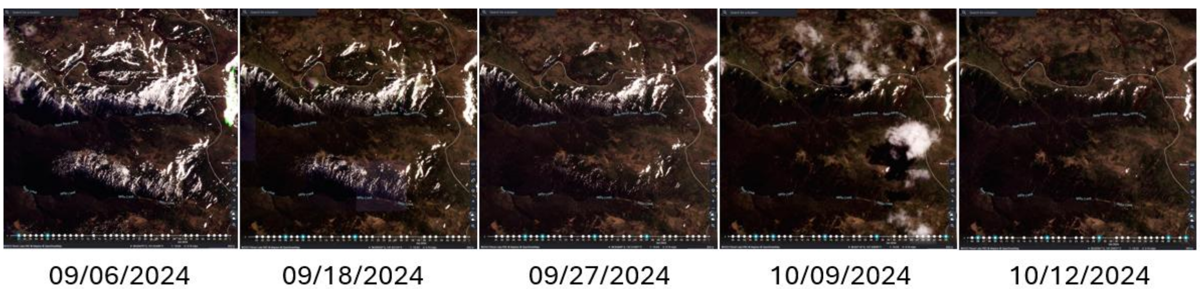

Figure 2. Example of snowmelt patterns in the Australian Alps as derived from PlanetScope.

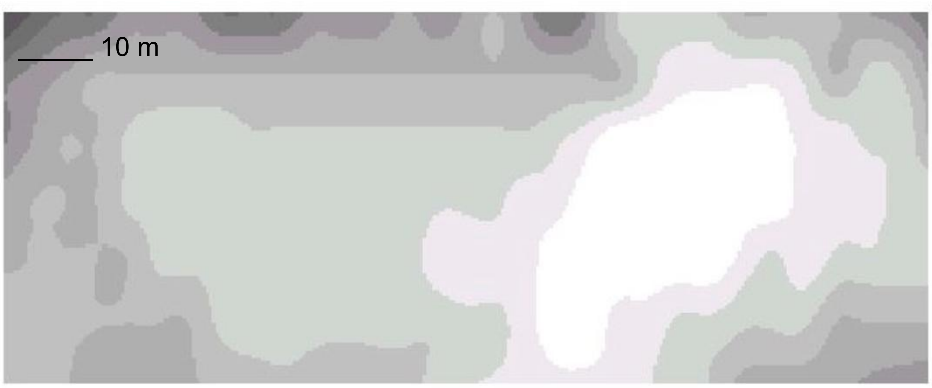

Figure 3. Mapped snowmelt zones within a snowpatch of different snowmelt timing. The snow melts early in the darker areas around the edge of the snowpatch, relative to the lighter areas in which the snow melts later.

Field site measurements (record on datasheet)

In each snowpatch snowmelt zone record these site characteristics:

1. GPS location in decimal format Latitude, longitude
2. Elevation (metres above sea level)
3. Aspect (with compass)
4. Slope (degrees with inclinometer or phone app)
5. Photograph a representative part of each snowmelt zone

In each snowmelt zone, record these vegetation characteristics:

1. Estimate the abundance of the target species in each snowmelt zone:
   R! (very rare): one or a few small individuals (this is unlikely, since you need 10 individuals of the target species)
   R (rare): some individuals at several locations, can hardly be overlooked in a careful observation.
   S (scattered): widespread within the section; the species cannot be overlooked but its presence is not obvious at first glance (not necessarily an evenly dispersed distribution over the entire summit area section).
   C (common): occurring frequently and widespread within the section – presence is obvious at first glance (cover is less than 50%).
   D (dominant): very abundant, making up a high portion of the phytomass, often forming more or less patchy or dense vegetation layers; species covers more than 50% of the area of the SAS (this is the only abundance class which is entirely related to cover).

In each snowmelt zone, record these environmental characteristics (if you can).

1. Soil moisture snapshot with probe (if you have one), measure next to each of the 10 target individual (10 measurements)
2. Estimate or measure when the snow melted in each zone.
3. Estimate or measure the number of snowdays for your sample season in each zone (using buried temperature loggers or remote sensing, regular photography etc) from when the snow covered the ground in Autumn to when it melted in Spring.
4. If temperature loggers are already in place, temperature information would of course be welcome.

In each snowmelt zone, record these target species characteristics (10 individual plants or patches of the target species). This should be achievable in a few hours, approximately 1 hour per snowmelt zone. Target individuals should be at least 1 m away from each other.

1) Target plant vegetative height (measure the distance from soil to the highest vegetative leaf)
generative height (measure to the highest point on the reproductive shoot). x 10 individuals in each snowmelt zone.

The target species in this example is *Luzula acutifolia*. The maximum vegetative height is 50 mm, and maximum generative height is 95 mm.

2) Target plant snapshot phenology, note the presence of buds/flowers/seeds developing/ seed dispersing/finished on the 10 target individuals in each zone

3) Target plant leaf area - On the target species, use the same 10 individuals that plant height was measured, measure leaf area of 1 leaf per plant. Choose fully expanded, mature, adult leaves. Include the petiole in the measurement of area. Either use the LeafArea app in the field, or remove leaves, take them with you to measure later with your preferred method.

5) Identify the 10 cm zone around the target individual

In the photo on the left, the target individual/patch is in the centre of the photo. The 10 cm zone extends from the edge of the individual/patch 10 cm perpendicular from that edge (within white lines).

6) Record presence of seedlings within 10cm of target individual or patch.
Record the presence of seedlings of the target species within a 10 cm radius of the target individual

Have a very close look for seedlings!

7) Estimate percentage of bare ground and rocks in the 10cm zone. Estimate to the nearest 5%.

8) Height of tallest 3 adjacent plants within 10cm of target individual or patch. Determine the tallest neighbouring species to the target individual and measure its vegetative and generative height (in the same manner that you measured the target individual. The three tallest adjacent plants might include plants that are the same species of your target or be all of the same species. If there are no flowers etc present, record this as zero. Use a 6 letter species code if necessary on the data sheet. For example, if *Aciphylla glacialis* is the first tallest neighbouring plant within 10 cm of the target individual, with a maximum vegetative height of 25 mm and flower height of 30 mm, write Aci gla 25, 30.

Justification of measurements: Plant height – indicator of relative competitiveness; leaf area – indicates relative productivity; reproductive stage – phenology at a point-in-time and reproductive effort and timing across snowmelt zones; composition survey – to evaluate richness and diversity; presence of seedlings – successful regeneration; Leaf area – resource investment into leaves/productivity; bare soil – opportunities for seedling recruitment; presence of rocks – less space for seedlings, but act as heat sink which promotes the growth of some adjacent species; soil moisture – a lasting effect of snowmelt timing.

For keen collaborators:
We discussed different levels of project involvement, but decided to go with the simple 1-day protocol for now. But if you are keen on more involvement please get back to us and we can plan advanced levels, such as: more than one target species, more traits, biomass, more visits per season, neighbour removals.

Timeline, manuscript and authorship:
Timeline: fieldwork in the northern hemisphere should happen at the peak of the alpine summer 2026 (July/August), and in the southern hemisphere at the peak alpine summer of 2027 (January/February).
Manuscript: After the data collection, we will write up a manuscript and invite all data contributors and contributors to the analysis as co-authors. If you are interested in getting involved in the analyses of the data, please get in touch with us.

Interested?
Please contact us and/or sign up in this google sheet:
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