Snow, Montane Wildflowers, and Citizen Scientists

The challenge of combining complex data to generate ecological forecasts

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Summary & Goals

The timing of key life events like reproduction (i.e. phenology) is tightly linked to climate. For example, alpine wildflowers emerge and flower within a few weeks of snow disappearance (Fig. 1), and complete their life cycles before first frost in early autumn. The timing of these wildflower displays is critical for the functioning of montane meadows, as a 'mismatch' between plants and their pollinators is problematic for both parties. The seasonal timing of snow disappearance and wildflower displays also influence visitation and staffing needs within parks. Resource managers and conservation biologists therefore need the ability to seasonally forecast snow disappearance and wildflower phenology. We will therefore combine diverse data sources with statistical modeling at Mt. Rainier National Park (Washington) to meet the following objectives:

- **Obj. 1)** Develop and validate seasonal forecasts snow disappearance date (SDD).
- **Obj. 2)** Develop and validate seasonal forecasts of peak wildflower displays.

Figure 1. Wildflower Meadows at Mt. Rainier National Park.

Objective 1: Seasonal forecasting of snow disappearance

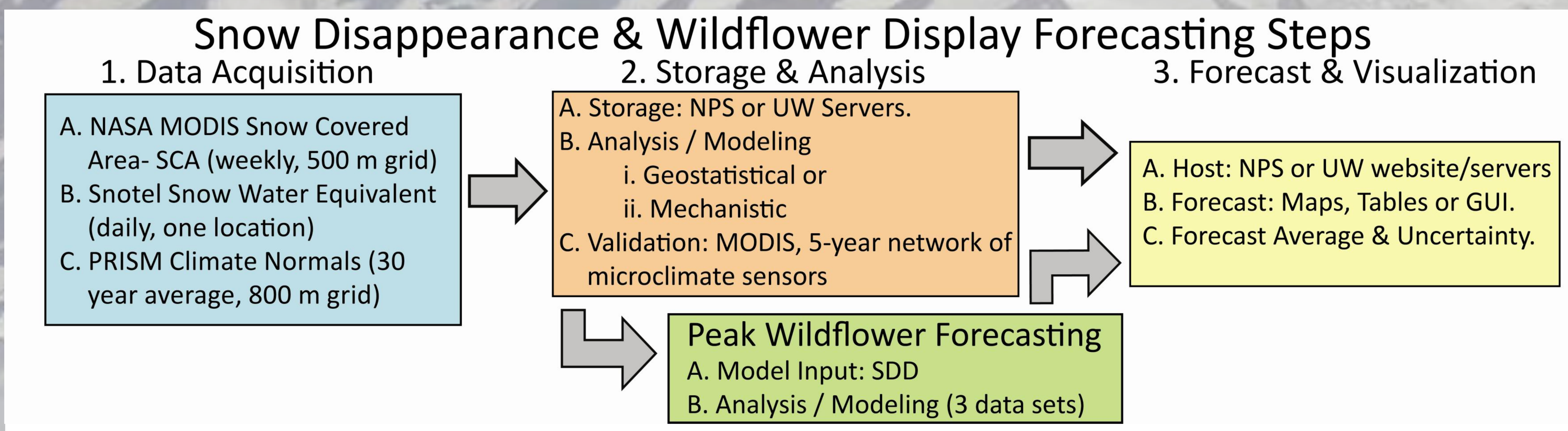


Figure 2. Snow & Wildflower Forecasting Tool Development, including proposed data inputs (1), analytical tool development (2) and forecast output (3).

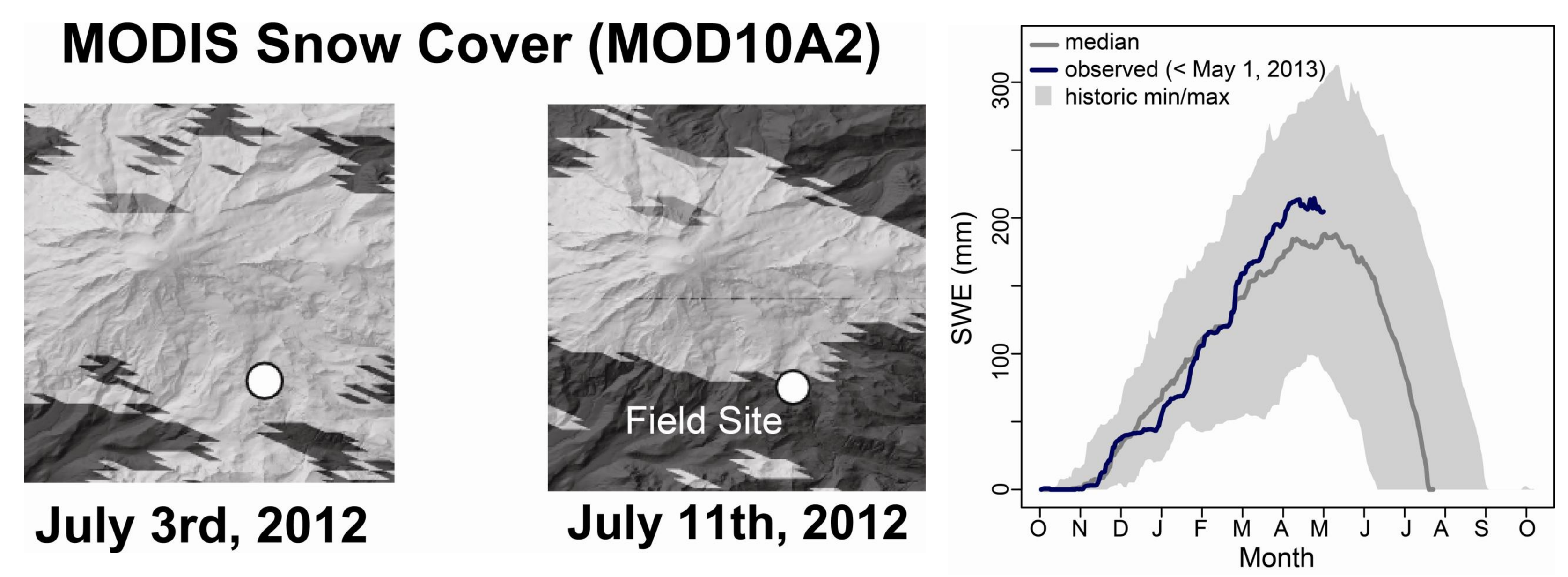


Figure 3. Inputs to snow forecasting tools include NASA MODIS images (A) documenting Snow Covered Area (SCA) and snow accumulation (B: Snow Water Equivalent – SWE) at the Paradise Snotel Climate Station (dot on maps in A).

Snow Forecasting Tool Development

Forecasting tools will provide weekly, spatially explicit forecasts of snow disappearance date (SDD) starting in March (Fig. 2).

- Model inputs: NASA MODIS Snow Covered Area (SCA - Fig. 3A), Snow accumulation (SWE - Fig. 3B), PRISM climate models (Fig. 4).
- Model Development: Geostatistical and/or mechanistic.
- Validation: Ten years of MODIS SCA (Fig. 3A), Five years of SDD from a microclimate sensor network (Fig. 5A&B).
- Forecasts: Spatially explicit estimates of SDD with associated uncertainty will be provided as maps and/or tables.

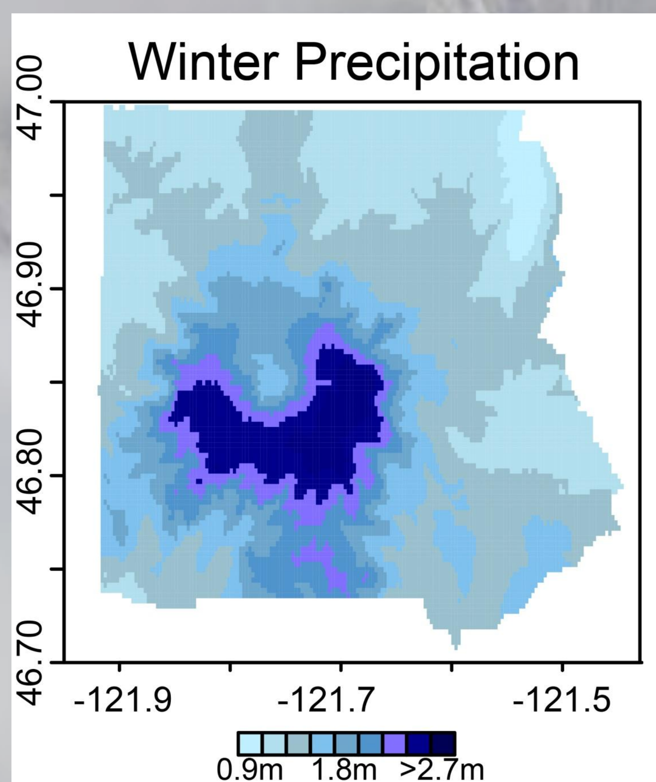


Figure 4. PRISM climate models (developed by Chris Daly at Oregon State University) provide spatial estimates of climate normals across Mt. Rainier National Park.

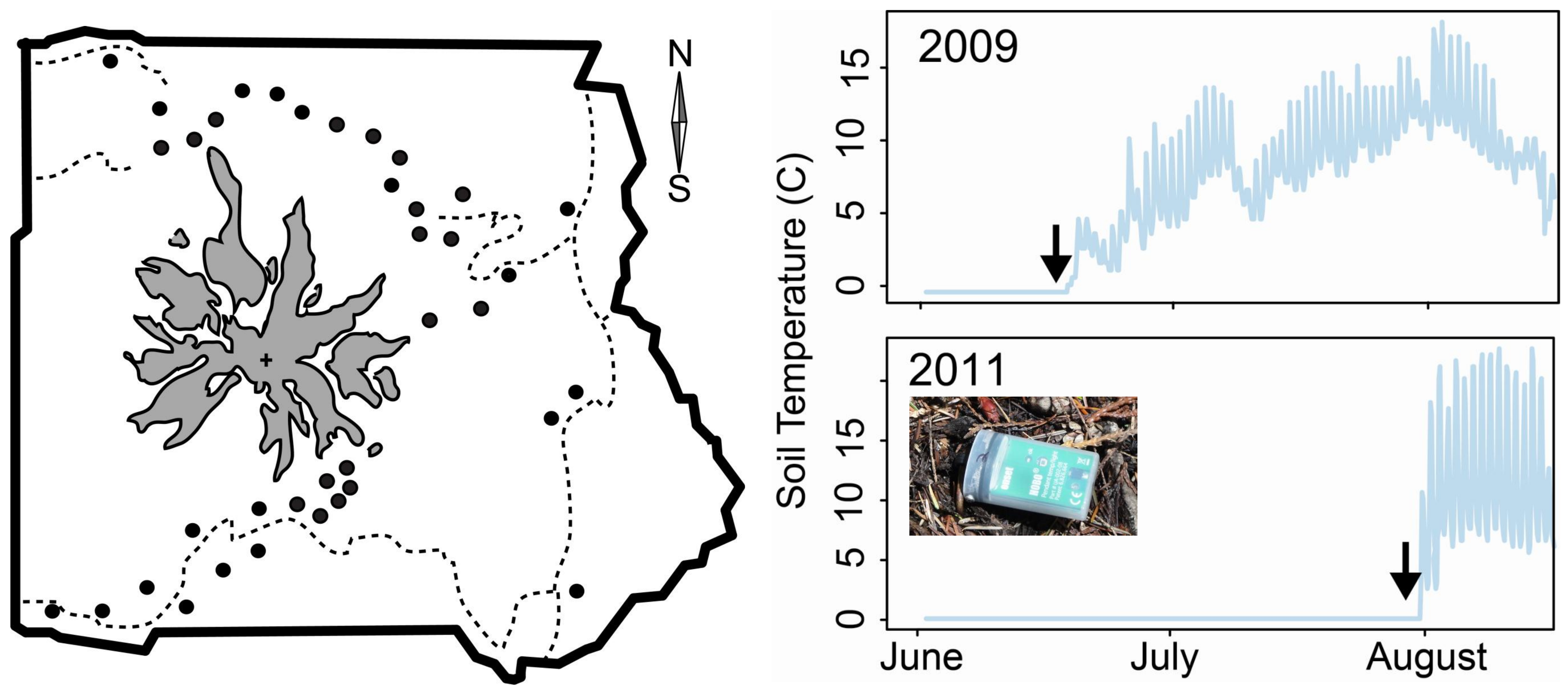


Figure 5. Snow forecasting tools will be validated with MODIS images (Fig. 3A) and a microclimate sensor network (A – each dot represents 2-24 sensors). Temperature readings from sensors (B) record annual snow disappearance dates (arrows).

Objective 2: Seasonal forecasting of peak wildflower displays

Peak Wildflower Forecasting Tool Development

Forecasting tools will provide live-updating, spatially explicit forecasts of peak wildflower displays starting in March (Fig. 2).

- Model Inputs: Snow Disappearance Date (SDD) & SDD uncertainty (Obj. 1).
- Data sources & Validation: A) Four years at ~70 locations recorded by Elli Theobald (Fig. 6); B) One year at 9 locations recorded by 48 citizen scientists (Fig. 7); & C) Five+ years from ~2000 geotagged and date-stamped photos (Fig. 8).
- Statistical Models: Wildflower Phenology ~ f(SDD) using maximum likelihood or Hierarchical Bayesian approaches.
- Forecasts: Spatially explicit maps of peak wildflower displays (per species, across species) with associated uncertainty, as maps or tables.

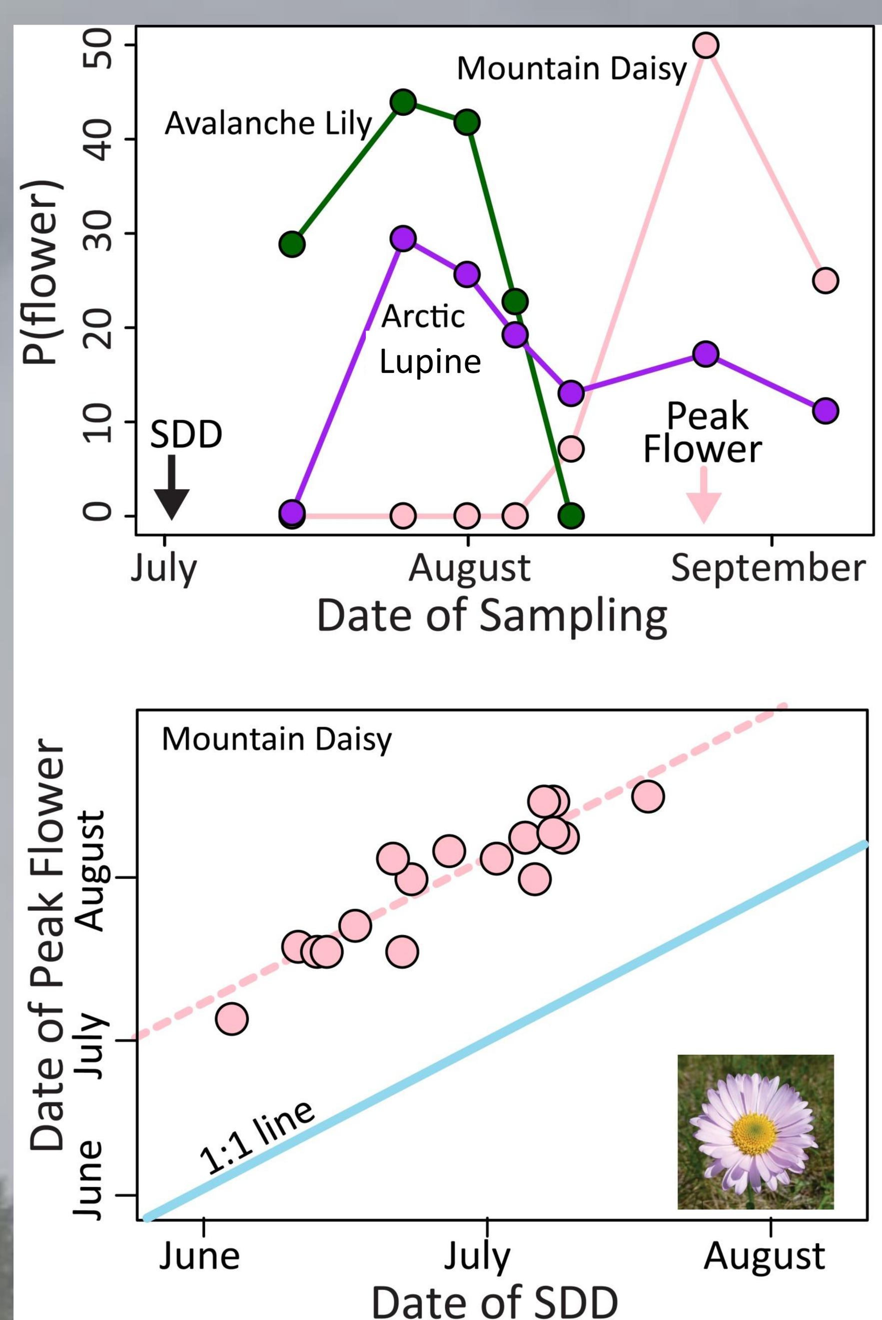


Figure 6. Observations of percent flowering and Snow Disappearance Date (SDD) collected over multiple years in individual plots (A) provide estimates of the relationship between SDD and peak flowering for individual species (B).

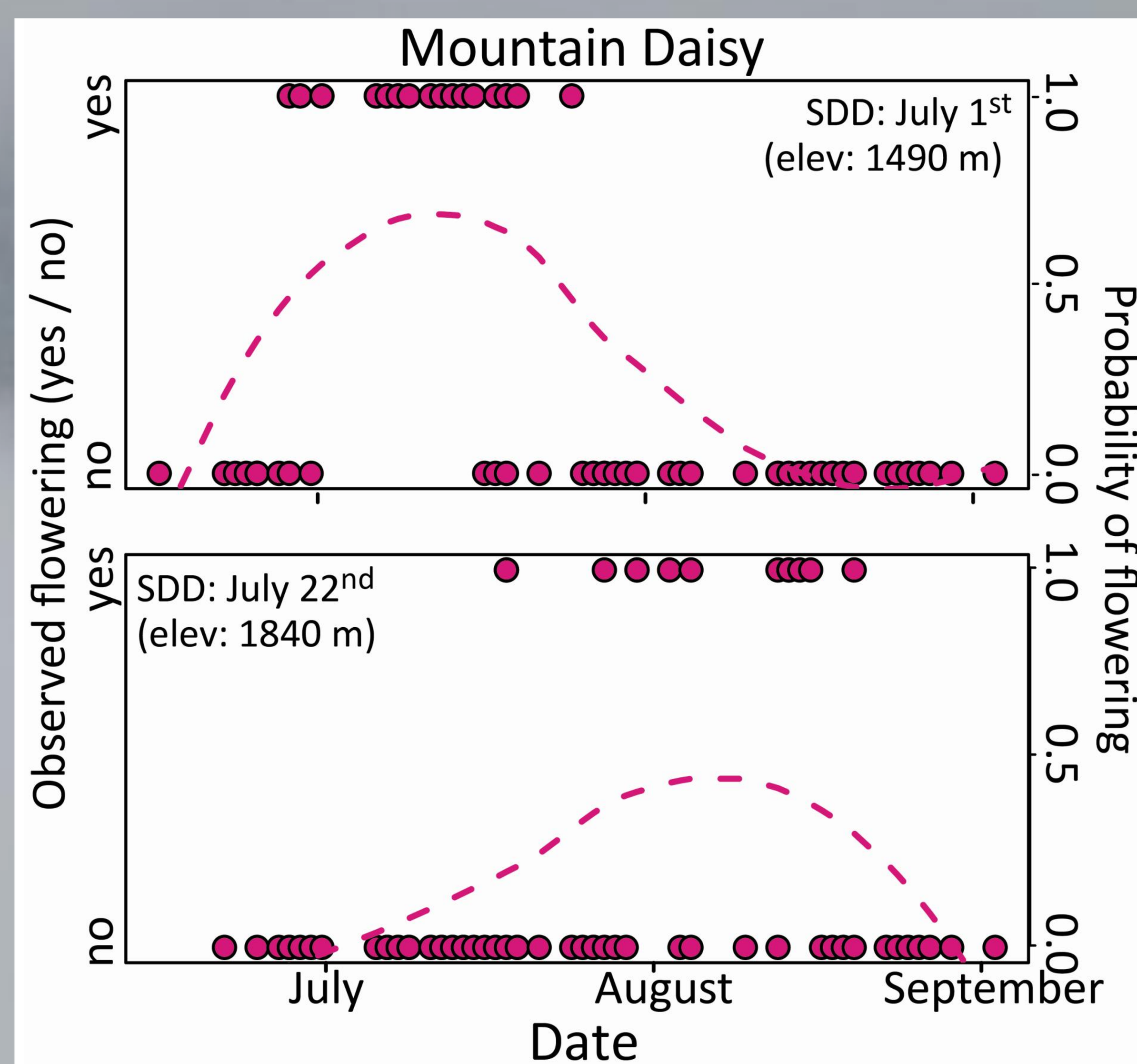
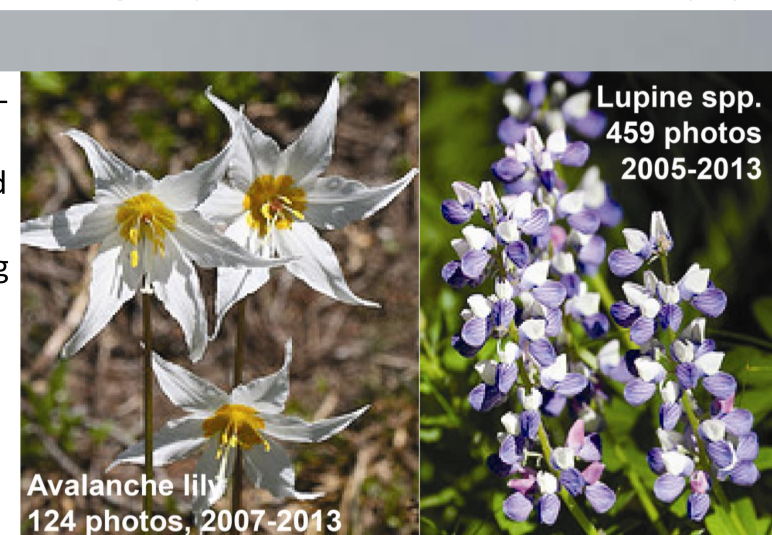


Figure 7. Observations collected by volunteers participating in the MeadoWatch Citizen Science Program provide estimates of wildflower displays relative to SDD.

Challenges

- Data inputs vary in spatio-temporal resolution and type.
- Automated data acquisition and processing.
- Data storage and management.
- Designing informative and useful forecasts for stake-holders.

Figure 8. Geo-tagged and date-stamped photos on photo-sharing websites provide estimates of the timing of wildflower displays.



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