Meeting Summary
Snow Collider • June 11, 2020

Overview

On June 11, 2020, the North Central Climate Adaptation Science Center (NC CASC), in coordination with CU Boulder Earthlab and CIRES and the US Fish and Wildlife Service, hosted a Snow Collider. This workshop brought snow data modelers and natural resource managers together to discuss and iterate on snow-related data and information needs, model limitations, and potential next steps for modeling future snow projections. The Collider was held virtually using Zoom.

Snow is a fundamental feature of the Rocky Mountains, with implications for numerous habitats, species, and ecosystem services. Climate change has the potential to alter this critical resource, with cascading effects on other systems and conservation targets. Modeling to develop snow projections for the North Central region is currently in the planning phase. The proposed modeling would build off and expand previous snow modelling work conducted for Glacier and Rocky Mountain National Parks. The goals of the Collider were to bring modelers and managers together to co-develop ideas to inform future modeling work:

- Short term: inform upcoming modeling of future projections of snow; specifically, regarding the most appropriate and useful model output metrics and their temporal and spatial extent, resolution, and summary.
- Long term: identify key data and science gaps, upcoming information needs, and how to move best available data into practice.

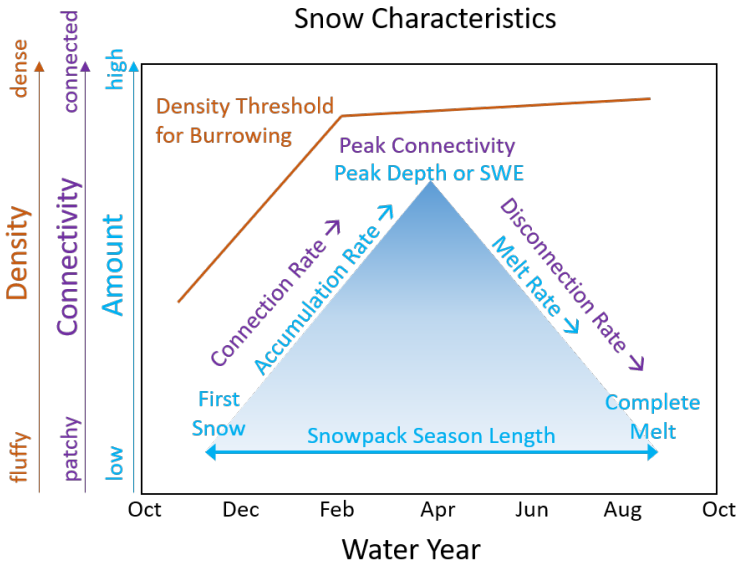
Summary

The Collider began with introductions and two overview talks followed by three rounds of "Colliding" during small group work. Attendees broke into three groups that related to their primary interest/expertise: 1) Water Resources and Quantity; 2) Terrestrial Species and Habitats; 3) Aquatic Species and Habitats. Every group had at least one manager ("data user"), one modeler ("data provider"), a facilitator, and a notetaker. The agenda is attached at the end of this document.

Pre-Survey

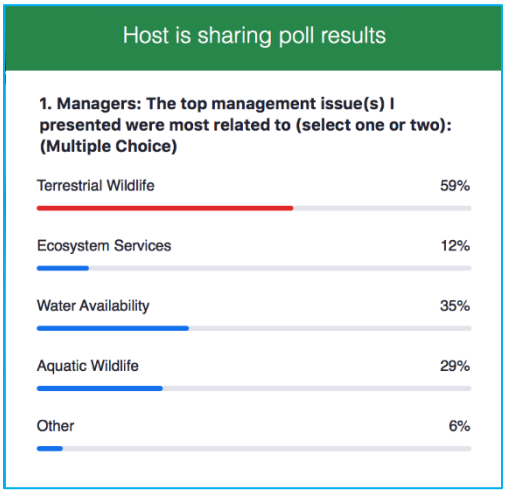
Prior to the Collider, organizers surveyed attendees about their primary interests in future projections of snow to guide Collider agenda planning.

The pre-survey also introduced a snow data type triangle to help attendees begin to think about ways in which snow data can be summarized (adapted from Rhoades et al. 2018). The "Snow Triangle" described three primary characteristics of snow (Density, Connectivity, Amount) and how those characteristics changed over time and could be measured.



Introductions

The twenty-nine workshop participants were made up of managers, modelers, and group facilitators representing a variety of organizations including, CU Boulder, the Colorado Parks and Wildlife, Montana Fish Wildlife and Parks, National Park Service, Bureau of Reclamation, USFS, NRCS, and the Wildlife Conservation Society.



We conducted two polls of attendees. The first suggested that most managers in attendance were primarily concerned with how future of snow would affect terrestrial wildlife.

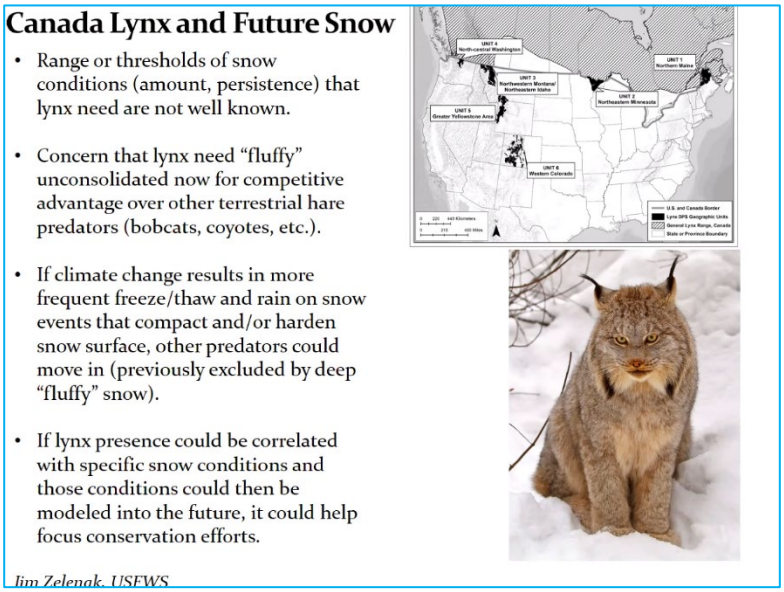
We also asked attendees to revisit the "Snow Triangle" and identify the types of future projections of snow data in which they thought they were most interested using Zoom's annotation feature. (This was also revisited later in the Collider. See marked up Snow Triangle on next page).

Modeling Overview

Ben Livneh, Assistant Professor in the Department of Civil, Environmental, and Architectural Engineering at CU Boulder, presented on past snow modeling work he and collaborators completed for Glacier National Park with a focus on identifying wolverine habitat. He discussed his primary modeling approach, limitations of the model, of ideas for model improvements.

Modeling Applications

John Guinotte, a Spatial Ecologist with the US Fish and Wildlife Service, discussed how resource managers can benefit from future projections of snow and presented a case study regarding future directions of snow modeling that could benefit Canada Lynx management.



Collision

Participants broke out into three groups during three rounds of "Collision", whereby "data users" and "data providers" worked together to identify model needs, limitations, and tradeoffs. Specifically the groups worked to 1) brainstorm key management decisions/issues for which their organization needed snow data, and then began to identify key data needs and gaps to address those issues; 2) identify the specific types of data that would be useful from future snow projection models, and 3) clarify model output specifications such as spatial and temporal resolutions, etc., that would be most useful. For each small group, we summarize these three rounds of Collision in the tables below, as well as note a few key comments and issues that arose. Many issues, questions, and thoughts arose during the Collider that were captured in the full proceeding notes but are not reflected here.

Water Resources and Quantity

Key management issues relevant to future projections of snow

- Determining water allocations to water users
- Determining reservoir operations during snowmelt

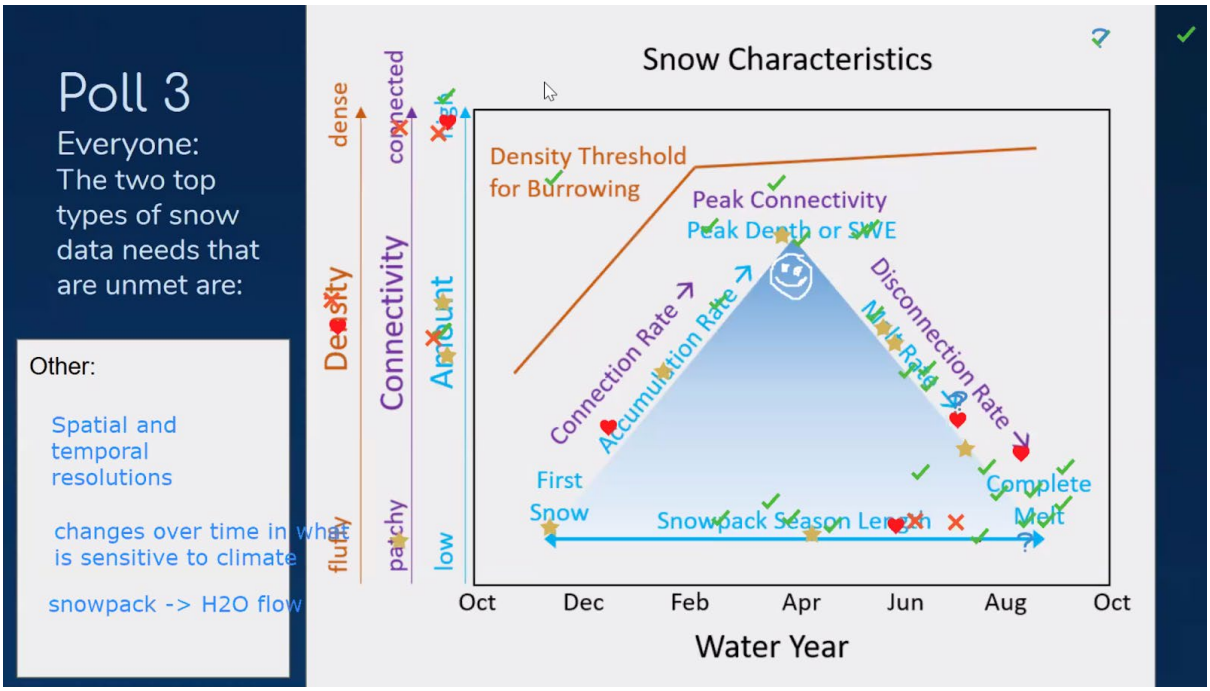
- Impacts of climate change-related shifts in SWE and effects on water supply, flood, and streamflow models
- Management of disturbances (e.g., burn scars) given changing snow conditions
- Sediment transport into reservoirs and interactions between precipitation, vegetation, and other disturbances

Key data gaps, needs, and specifications

- SWE is arguably the most useful measurement for a broad-spectrum of management questions
    - Seasonal volume forecasts
    - 50-250m spatial resolution of SWE across the management domain (CONUS)
    - Weekly or bi-weekly temporal resolution
- Melt rate is important for assessing sedimentation as well as informing reservoir operations
    - Daily resolution most desirable in context of flood control
    - Improved short term forecasts with longer lead times
- Better models of rain on snow events and understanding of how precipitation generates snow melt depending on precipitation type and existing snow conditions (e.g., snowpack temperature and maturity)

Other issues

- There is difficulty in relating the scale of the global climate model outputs and the scale of management decisions
- Need for higher elevation and more heterogeneous observations to capture the spatial variability of snowpack
- Need for process models to account for finer scale processes
- Need tools and methods to reliably assess uncertainty in models
- Need to develop more sophisticated models to make better use of the new data products that are available
- Need to understand how the process and statistical models are using the available data
- Need for long term data for calibration of the non-physical model



Terrestrial Species and Habitats

Key management issues relevant to future projections of snow

- Specific species (numerous examples) and specific snow-related data including:
    - Wolverine, lynx, mountain lion denning habitat – access to enough snow of the appropriate texture
    - White-tailed Ptarmigan or Greater Sage-Grouse seasonal ranges and migration

    - Pika, wolverine, ptarmigan, bears, greater sage-grouse need snow to moderate environment
    - Ungulate access to forage
- Guidance on which model results are suitable for guiding which management decisions
- Where to focus management interventions such as protection and restoration
- Extreme and cascading events - extremes are when management decisions come into play

Key data gaps, needs, and specifications

- Snow texture
- Snow depth and density over longer timescales
- Timing of peak runoff
- Snow extent and connectivity and snow free area: daily and longer
- Specific locations where quality and quantity of snow are most likely to persist over time
- Spatial and temporal shifts in extreme events
- Last potential snow accumulation date
- Most data needed over range of spatial and temporal extents and resolutions
- Alternative summary of total water to replace April 1 SWE in low-elevation locations

Other issues

- Data output specifics are so context and issue dependent it is difficult to summarize
- Several needs are for day to day management, but several for climate change adaptation
- Data needs to be useable for specific species

Aquatic Species and Habitats

Key management issues relevant to future projections of snow

- Altered flow and disturbance regimes
- Snow location and amount relative to aquatic systems
- Water temperature regime (ground and surface)
- Ecosystem transition and ecological integrity

Key data gaps, needs, and specifications

- High resolution temporal and spatial scale data on snow depth, spatial distribution of cover, catchment SWE, and snow data – and data coupled with resulting streamflow and temperature
- Water temperature regime (ground and surface) and groundwater characteristics including interaction with surface water: Recharge/discharge rates and locations
- Density of snowfall
    - Peak depth
    - Precipitation timing, amount, and form (rain vs. snow)
    - Average melt-out date, melt rate, complete melt, and locations with higher resistance to accelerated snow melt
    - Seasonal variation among watersheds
    - Mid and long-range projections: although long range models inherently have greater uncertainty, many population-level species recovery happens across extended time horizons
    - More observational data and increased density of monitoring network (SNOTEL, RAWS, etc) and precise calibration data at known locations (i.e., like wolverine den locations) to train spatial models; better coverage of high-elevation snowpack

Other issues

- Substantial need to better understand and incorporate uncertainty
- Many models not being used as well as they could due to expense of creating and archiving them
- Data output specifics are so context and issue dependent it is difficult to summarize

Wrap Up and Ideas for the Future

- Interest in snow information at all scales
- Physical characteristics of snowpack were more important than expected
- Mismatch often between future climate data scales and desired snow data scales
- Substantial differences in data needs depending on planning horizon; consider both short and longer term
- Unlikely to settle on one model, one output, one scale. These types of meetings are needed in ongoing manner to ensure continuous dialog to ensure management-relevance of models
- Consider dividing problem into broad divisions like accumulation season; large events; connective snow vs. large scale snow- can help determine which models are most appropriate; Focus on processes in different regions (Alpine, boreal, mountain) and how that interacts with scale
- There was significant discussion concerning uncertainty: balance between uncertainty and model rigor; importance of communicating uncertainty and translating this into usable information; critical to understand model limitations, but from managers perspective they would rather have imperfection than nothing
- Ideas moving forward:
    - Need for models of future of flow connected to future of snow
    - Consider ongoing focus groups with management groups to gather specific information on data needs
    - Consider following up with webinar series on snow modeling
    - Consider providing a “how to guide” that listed different snow data products and key model differences/limitations

A Few Lessons Learned

- A post-Collider survey was completed by 12 of the 19 attendees who were not involved in the planning of the event
    - There were unanimous responses that participation increased knowledge regarding snow projections and data products, and attendees learned about new materials, tools, and resources that they could use in the future
    - Almost all sessions were found to be useful and very useful; two sessions had 1-2 responses that they were only somewhat useful: the 2-minute lightning talks provided by managers and the final Collision session designed to detail data output specifics, like spatial and temporal scale and resolution
- The process of dialog is more important than the product – determining specific data outputs and types
- Shorter sessions over multiple days would be more easily considered/attended; that was manager attrition over the course of the day
- Managers are busy and hard for them to find the time to engage even if they see the benefit
- Google Sheets are a free, but clunky way to collaborate. There were several attendees who noted that pressure to fill out the Google Sheets could stifle conversation, and a more “guiding question”, free-form approach might work better. In general, the format of the sheets (and indeed, the structure of each collider session) was perhaps not a major obstacle, but they should be rethought and improved (or discarded?) for future efforts
- The small group discussions really do work in a virtual environment
- The workshop focused on small-group work; attendees agreed it would be good pair with a webinar series or a method of deeper dives into a single topic/model/approach
- There are many intelligent, interesting, articulate people working in areas that are relevant to snow data!

Agenda

Time	Topic
8:45 AM	Early sign-on and virtual coffee chat
9:00 AM	Welcome, background, and overarching goals of meeting
9:10 AM	Some basic Zoom rules
9:20 AM	Introductions (Aparna Bamzai Dodson)
9:40 AM	BREAKOUT: Informal meet and greet
10:10 AM	Poll 1 - Key management issues related to future projections of snow (managers)
10:15 AM	Poll 2 - Types of snow data related to key management issues (managers)
10:25 AM	Modeling overview (Ben Livneh)
10:45 AM	Modeling applications (John Guinotte)
10:55 AM	Break
11:10 AM	BREAKOUT: Brainstorm - what are priority management issues that could be informed by projections of snow
12:10 PM	Lunch
12:40 PM	Word Cloud - Brainstorm Results: management issues, data gaps
12:55 PM	Brainstorm Report Out
1:25 PM	BREAKOUT: Collider Part 1 - data needs and types
2:10 PM	Poll 3
2:15 PM	Break
2:20 PM	Word Cloud - key desired model output metrics and measures
2:35 PM	BREAKOUT: Collider Part 2 - data specifics
3:20 PM	Collider Report Out
3:50 PM	Break
4:00 PM	Summary: What managers heard (John Guinotte and Sean Finn)
4:10 PM	Summary: What modelers heard (Ben Livneh)
4:20 PM	Summary and Discussion
4:50 PM	Wrap up and next steps
5:00 PM	Adjourn