

The Costs of Climate Change: Impact of Future Snow Cover Projections on the Valuation of Albedo in Forest Management



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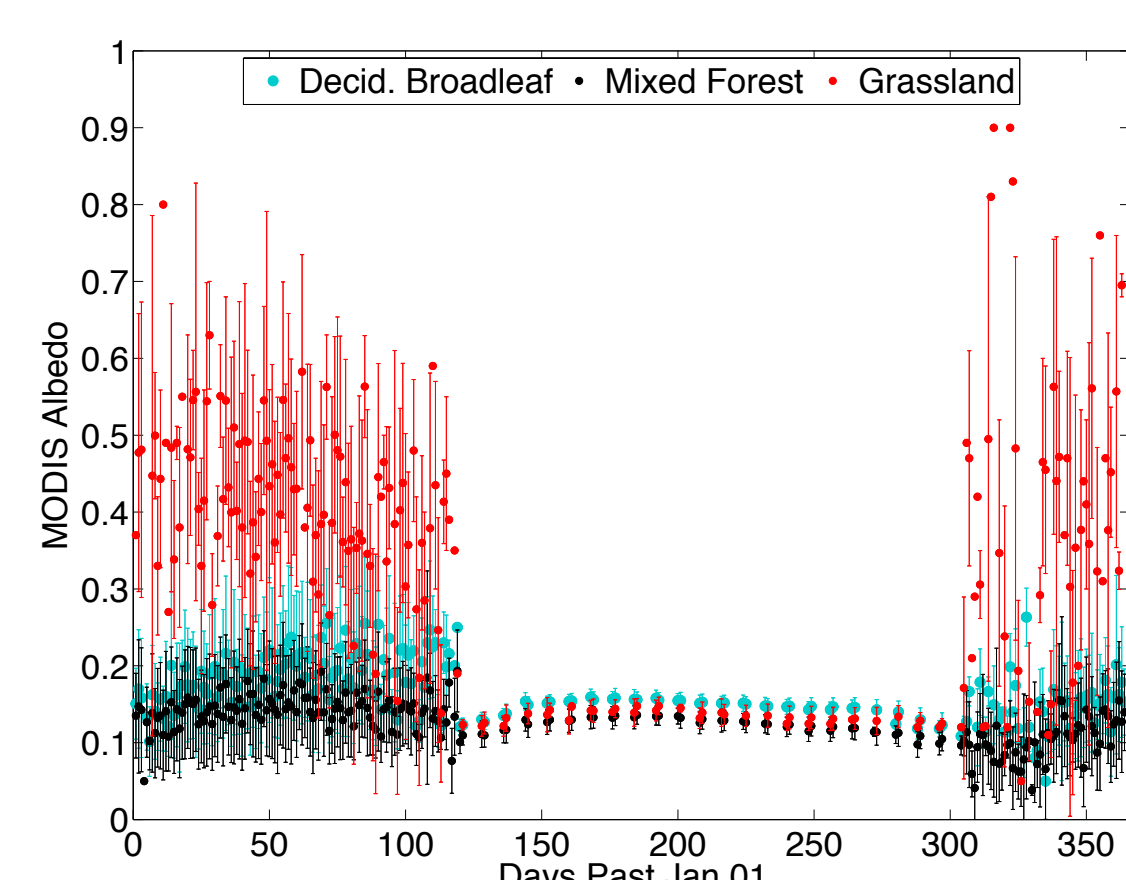
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Albedo As a Climate Regulating Service

Surface albedo regulates climate by controlling reflected and absorbed surface energy fluxes. High albedo snow cover reflects incoming solar energy cooling the surface. Low albedo forest canopies absorb energy and are warmer relative to adjacent snow-covered lands¹. Here, we assign economic value to albedo and evaluate it with timber and carbon value² through 2100 using SRES A1 and B1 scenarios.



Seasonal cycle of MODIS albedo, 2002-2013.

Will Albedo Value Decrease by 2100?

- Simulate future changes in albedo for forested and harvested land cover states
- Evaluate the impacts of future surface albedo on radiative forcing
- Quantify future trade-offs associated with forest management due to albedo, carbon storage, and timber value

Datasets

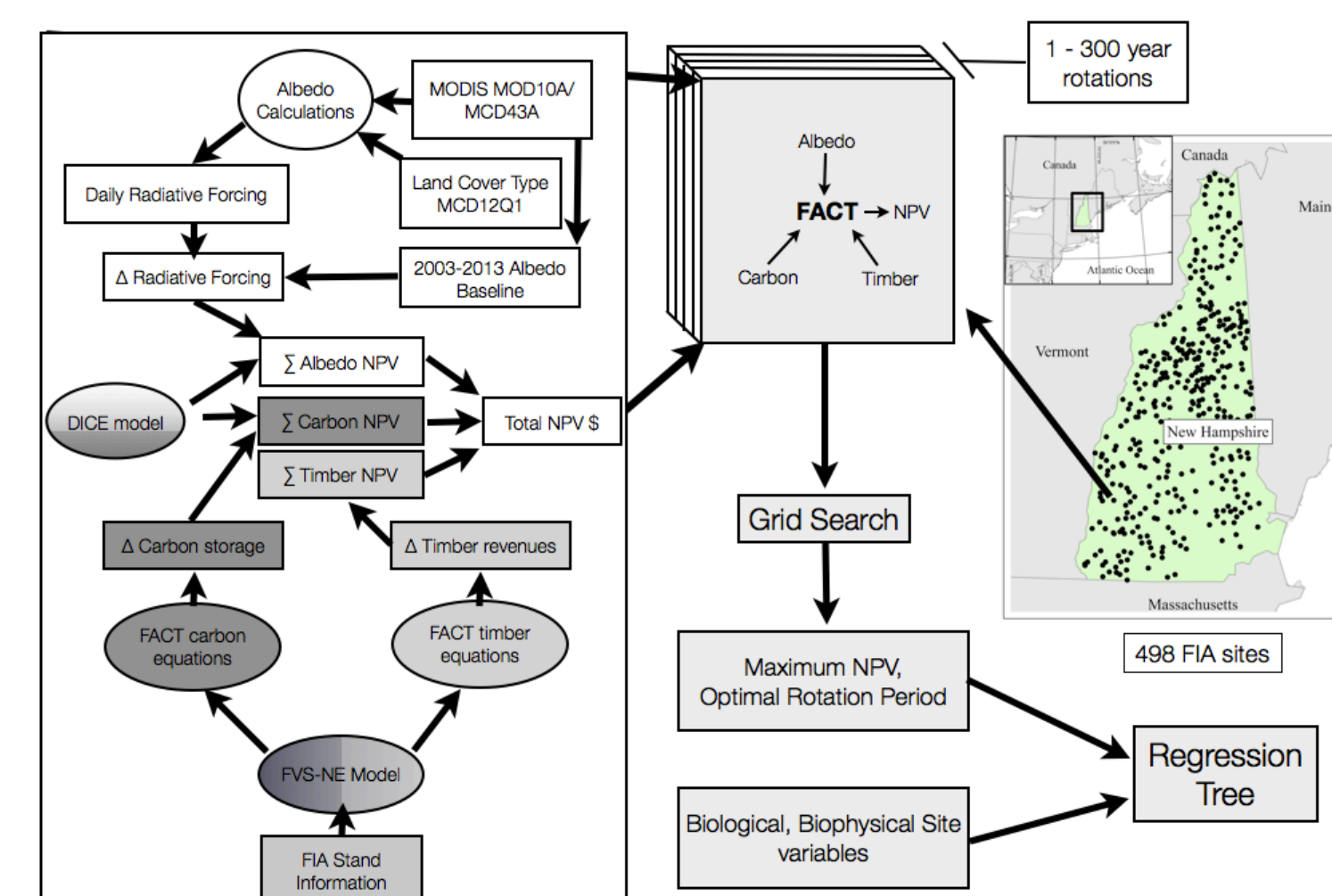
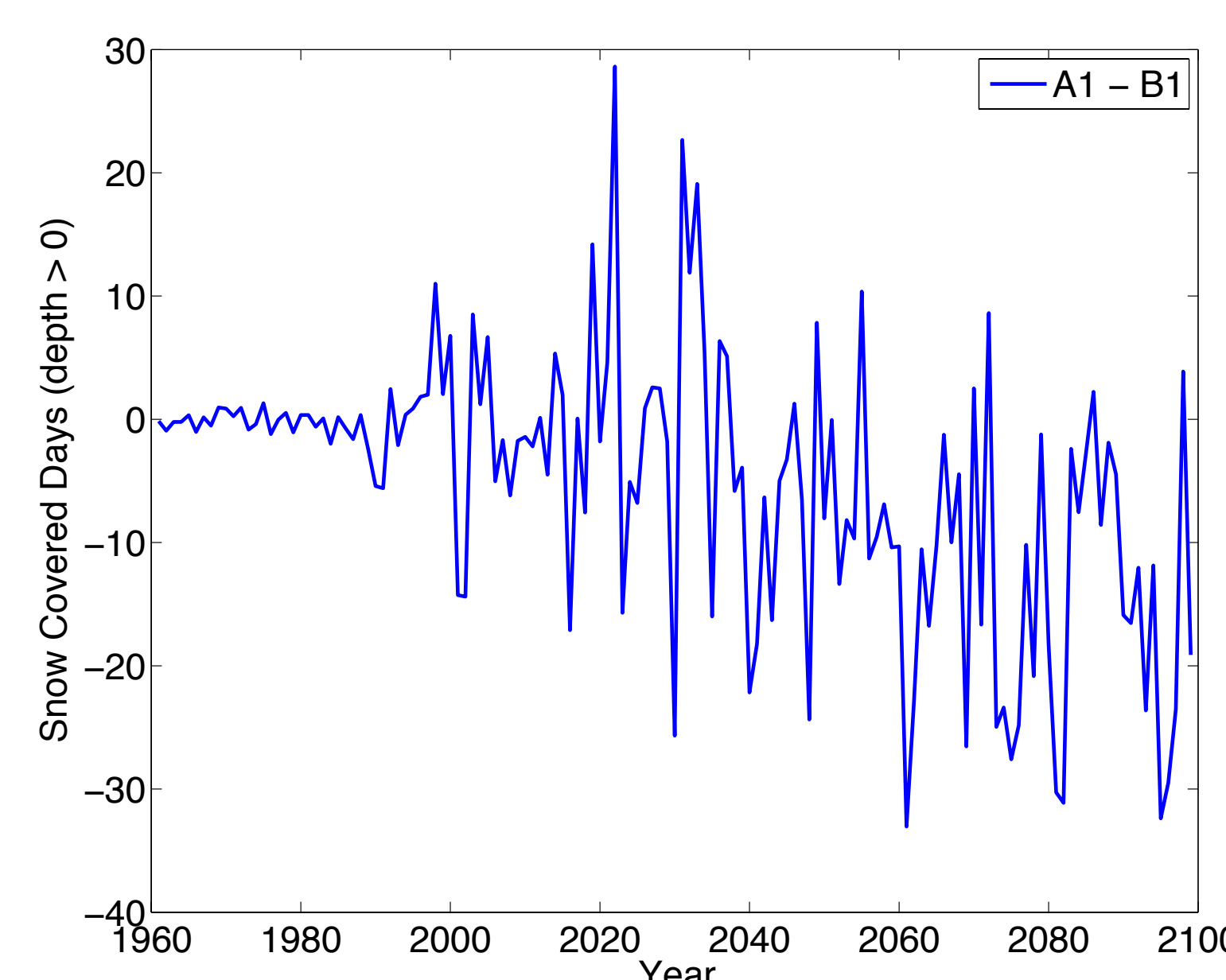
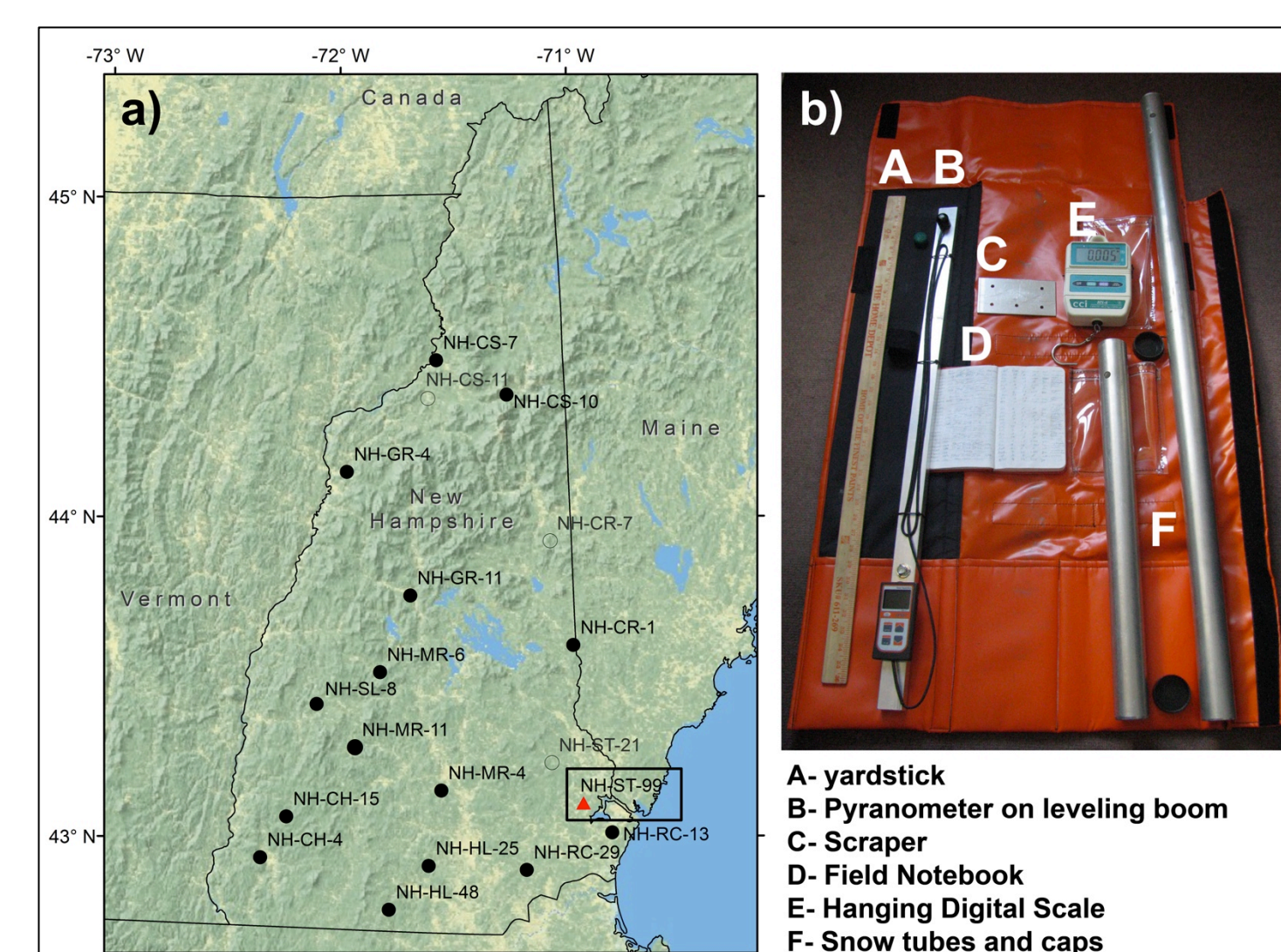
Community Collaborative Rain, Hail, Albedo, and Snow Network Daily Snow Depth and Albedo³
MODIS:

- MCD43A 16-day BRDF-Adjusted Albedo
- MOD10A1 Daily Snow Albedo
- MCD12Q1 Annual Land Cover

Forest Inventory and Analysis (FIA) Program Statistics
Daily Future Snow Depth Projections for SRES A1 and B1 scenarios, 1960-2100⁴

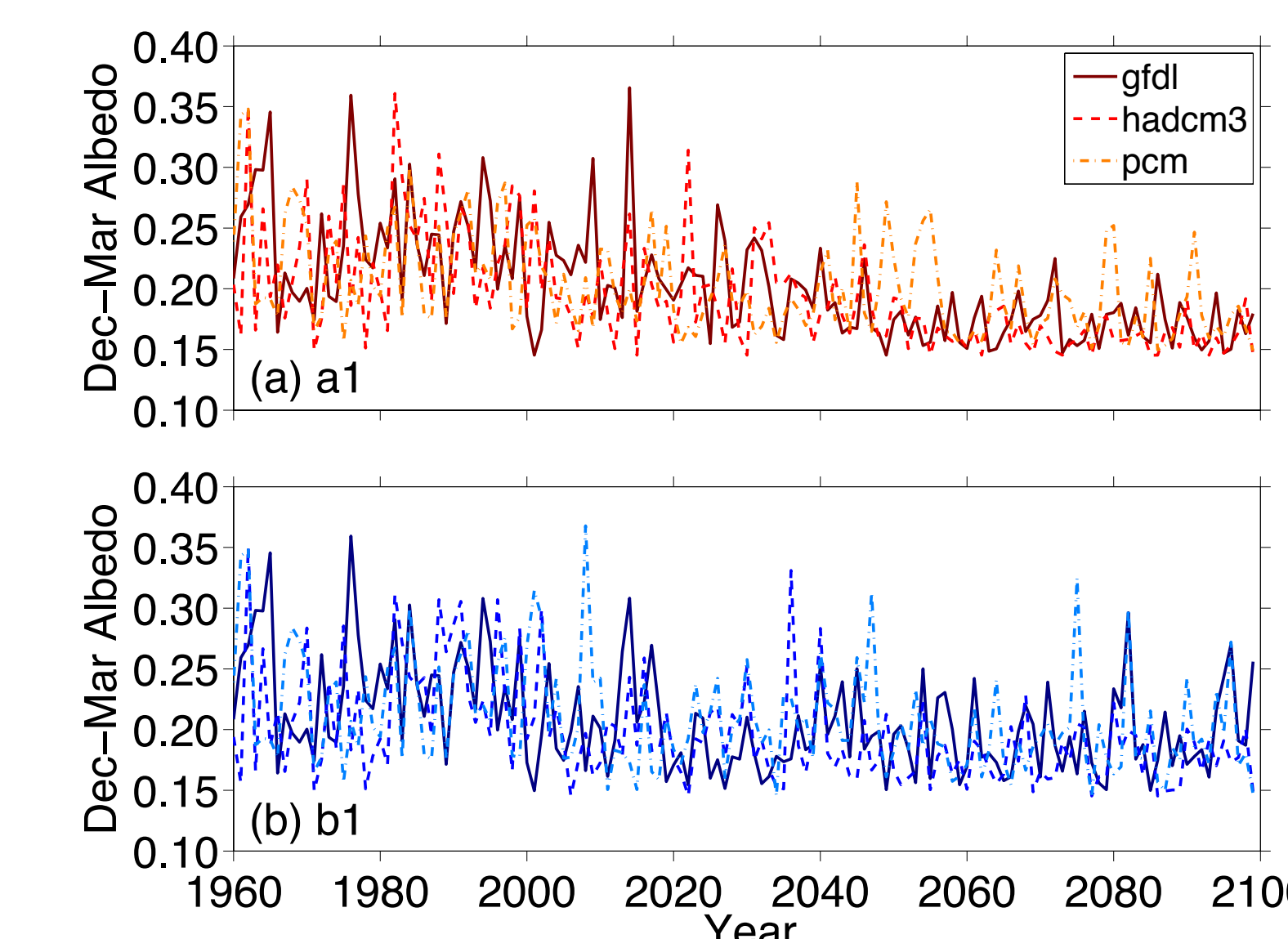
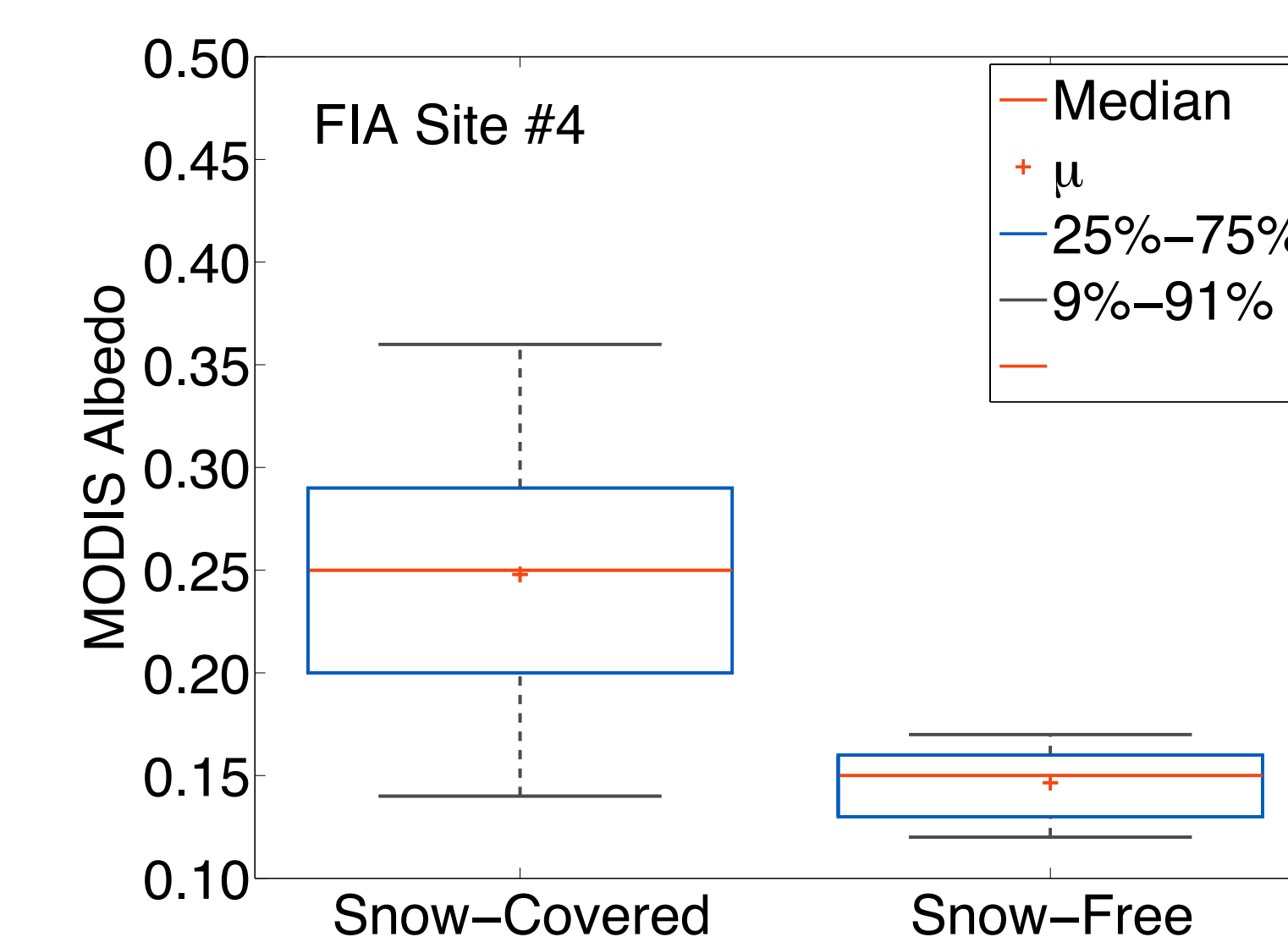
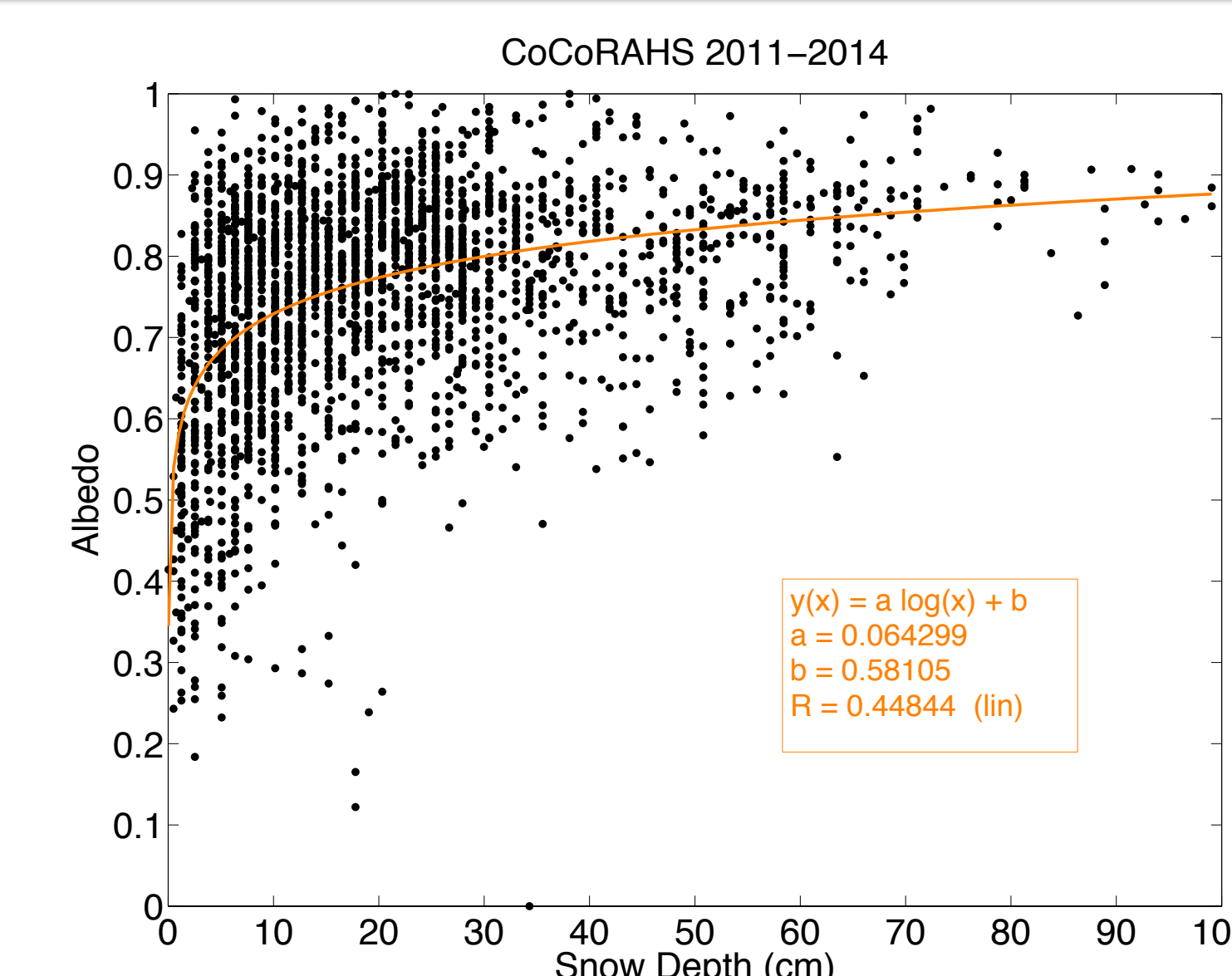
Approach

1. Establish relationship between snow depth and albedo for deforested lands in the CoCoRAHS Network.
2. Calculate average MODIS snow-covered (MOD10A1) and snow-free (MCD43A3) albedo for FIA forested sites, 2002-2013.
3. Use A1 and B1 snow depth projections to estimate future forested and deforested albedo at FIA sites.
4. Evaluate change in albedo radiative forcing to carbon storage and timber value to determine optimal harvest rotation period.



Results

- The CoCoRAHS Albedo Network provided a robust relationship between snow depth and albedo across the state of New Hampshire.
- A sensitivity analysis demonstrated that predicted albedo was not sensitive to the range of logarithmic parameters observed in the CoCoRAHS dataset.
- Snow-covered albedo at the forested FIA sites have greater variability than snow-free albedo.
- Maximum snow-covered albedo for forested sites (0.33) is substantially lower than maximum snow-covered albedo at deforested sites (0.53).
- Insignificant difference in snow-free albedo.
- Very little intermodel variation in projected albedo based on snow depth projections.
- By the end of the century, winter (Dec-Mar) albedo decreases more in the A1 scenario than B1 scenario.



Conclusions and Future Work

- Greater decreases in snow depth under A1 scenario leads to larger differences in albedo for forested and harvested states
- Trade-offs among albedo, carbon, and timber need to be evaluated to account for decrease in future snow cover.

References:
¹Mote, T.L. 2008. On the Role of Snow Cover in Depressing Air Temperature. *Journal of Applied Meteorology and Climatology*, 47: 2008-2022.
²Lutz and Howarth, 2014. Valuing albedo as an ecosystem service: implications for forest management. *Climatic Change*, 124: 53-63.
³Burakowski et al. 2013. Putting the Capital 'A' in CoCoRAHS: An Experimental Programme to measure albedo using the Community Collaborative Rain, Hail, & Snow (CoCoRaHS) Network. *Hydrological Processes*, 27(21): 3024-3034.
⁴Hayhoe et al. 2007. Past and future changes in climate and hydrological indicators in the US Northeast. *Climate Dynamics*, 28: 381-407.