

The Impacts of Reforestation on Winter Surface Albedo in the Northeastern United States

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Background

Reforestation in New England began between 1850 and 1870, after a long period of colonial-era land clearing for sheep and cow pasture, wood products, and fuel to warm homes (Figure 1).

The connection to cheap, mid-Western US grain via rail led to pastureland abandonment and the shift to coal fuel in the late 1800's sparked off a region wide reforestation trend that continued through the 1960's.

Present day loss of forest cover from 1960 to present is due primarily to development and urbanization.

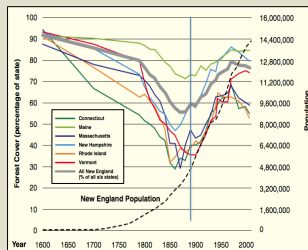


Figure 1. New England forest cover and population, 1600-2000. Foster et al. 2010

Albedo is the ratio of outgoing to incoming solar radiation, or reflectance (Figure 2). Remote sensing by the MODerate resolution Imaging Spectroradiometer reveals a consistent pattern of lower surface albedo over forested landscapes and higher albedo over unforested landscapes (Table 1; Figures 3-5).

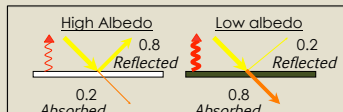


Figure 2. High albedo surfaces (left) reflect more and absorb less incoming solar radiation than low albedo surfaces (right), leaving less radiation available to be emitted as heat.

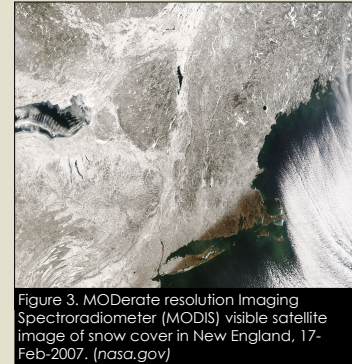


Figure 3. MODerate resolution Imaging Spectroradiometer (MODIS) visible satellite image of snow cover in New England, 17-Feb-2007. (nasa.gov)

Research Questions

Primary research question:

How did winter climate in the Northeastern US respond to historical changes in land cover?

Sub-questions:

1. How does present-day surface albedo vary spatially and temporally between and within land cover types?
2. How has surface albedo responded to historical land cover changes?
3. What has been the change in net surface radiation in response to historical land cover changes?
4. What was the temperature response to changes in net radiation, both above and below forest canopies?

Preliminary Results

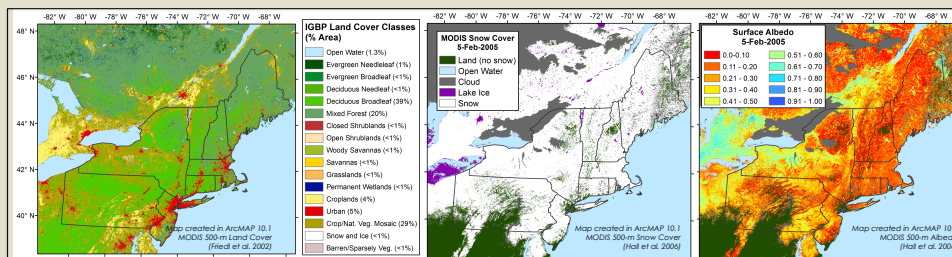


Figure 4. MODIS 500-m land cover (left), snow cover (middle), and albedo (right) for 5-Feb-2005. Albedo values are shown for snow-covered surfaces only. Higher albedo surfaces in colors, lower albedo surfaces in warm colors.

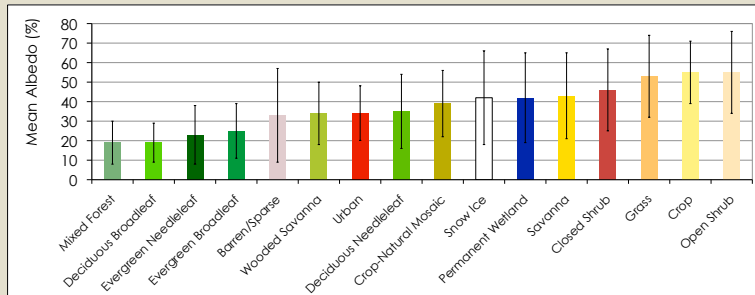


Figure 5. Mean snow-covered surface albedo for land cover types in the Northeastern US, averaged for winter (DEC-FEB) months over the period 2001-2005. Error bars represent one standard deviation (Burakowski and Wake, 2010).

Future Work

Part I: In-situ albedo network

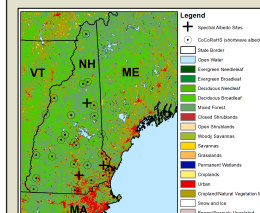


Figure 6. Proposed broad-band shortwave (⊙), spectral (+), and aircraft-mounted hyper-spectral albedo will be measured over a variety of land cover types in New Hampshire.

Objectives:

1. Validate MODIS forest albedo (previous studies limited to unforested regions)
2. Characterize temporal and spatial variability of albedo
3. Improve and refine MODIS snow cover and albedo algorithms

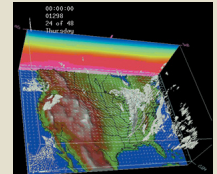
Instrumentation:

- Shortwave broadband- Licor LI-200sa Pyranometer
- Spectral - Eppley Precision Spectral Pyranometer
- Aircraft-Mounted Hyperspectral - AISA Eagle/Hawk Imaging Spectrometer



Part II: Regional Climate Modeling

The **Weather Research and Forecasting (WRF) Model** is a free and shared regional climate model with distributed development and centralized support at the National Center for Atmospheric Research (NCAR) in Boulder, CO.



Research Plan:

1. Model parameterization and optimization- tune and refine model settings for the Northeastern US
2. Model experimentation- run model for 5-year simulations using present day and historical (Figure 7) land cover scenarios to characterize climate responses to reforestation.

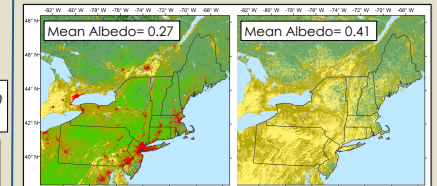


Figure 7. Proposed land cover scenarios for present-day (left) and 1870 (right). Historical land cover scenario generated by converting all present-day deciduous broadleaf and urban classes to cropland.