

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

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## Introduction

The peak of deforestation in the Northeastern United States occurred around 1850, with nearly 75% of the region having been cleared for pasture and timber harvest (Foster et al. 2008). Today, nearly 60% of the region is now reforested. Few studies to date have investigated the climate impacts of reforestation on Northeastern US climate. While reforestation may have served to cool summer climate in the region through increased rates of evapotranspiration (Roy et al. 2003), the climate impacts of reforestation in winter remain unknown. This research investigates the potential magnitude of snow-covered surface albedo change induced by reforestation.

## Research Questions

1. Are there significant differences in snow-covered surface albedo for different land cover types in the Northeastern United States?
2. Could regional-scale reforestation have significantly changed wintertime surface albedo?

## Datasets

### MODIS Snow Cover and Albedo (V5) MOD10A1

- Daily 500-m coverage
- Snow cover uses Normalized Snow Difference Index (Bands 4&6)
- Band 6 on Aqua failed shortly after launch, only Terra data used
- Albedo adjusted for slope and topography using bidirectional reflectance distribution functions
- 58 winter (Dec-Feb) scenes with less than 30% cloud cover between 2001-2005
- Surface validation is ongoing, estimated 10% error

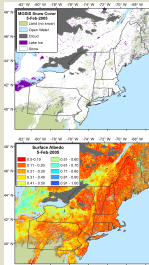


Figure 1. MOD10A1 V5 daily snow cover (top) and surface albedo (bottom) for 5-Feb-2005 (Hall et al. 2006).

### MODIS Land Cover MCD12Q1

- Annual 500-m coverage
- Supervised decision-tree classification method
- Seventeen IGBP land cover classes
- Extensive surface validation

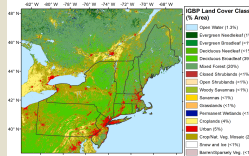


Figure 2. MCD12Q1 International Geosphere Biosphere land cover classes (IGBP) for the Northeastern US in 2002. (Friedl et al. 2002).

## Methods

### 1. Averaging snow-covered surface albedo of MODIS land cover types

The mean snow-covered surface albedo is calculated for each of the sixteen land cover types (excluding open water) using granules available over the period Dec 2000-Feb 2005 that meet the following quality criteria: (1) less than 30% cloud cover, and (2) have an assigned quality flag "inferred passed". The number of granules used by tile ID and year is summarized in Table 1.

Table 1. MODIS snow cover and albedo granules. The ID boundaries illustrated in Figure 5.

MODIS Tile ID	2001	2002	2003	2004	2005	Total
h11v05	3	6	1	2	3	15
h12v04	0	1	0	0	0	1
h12v05	2	1	2	5	1	11
h13v04	4	5	3	3	3	18
Total	9	15	6	10	7	47



MODIS visible satellite image of a snow-covered Northeastern US on 19-Feb-2007. (nasa.gov)

### 2. Calculating change in snow-covered surface albedo from reforestation

Nearly all forests in the Northeastern US are less than 150 years old. An historical land cover scenario is developed such that all present-day deciduous and evergreen forest land cover classes are converted to cropland. The 1850 land cover scenario in this study represents a conservative estimate of deforestation compared to other estimates (e.g., Foster et al. 2008).

The present day MODIS snow-covered albedo values are applied to the historical land cover scenario and a regionally averaged albedo is calculated for (a) 1850 land cover and (b) present day land cover, assuming the entire Northeastern US is covered with snow.

## Results

Figure 3. Mean snow-covered surface albedo for the sixteen IGBP land cover types (no open water) in the northeastern US, as measured by MODIS Terra daily 500-m snow-covered albedo during winter (December-February), 2001-2005. Error bars represent one standard deviation (σ).

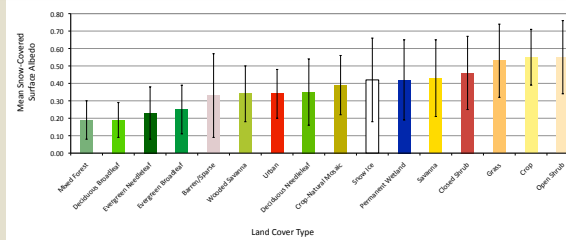
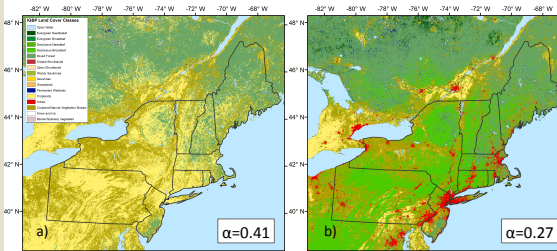


Figure 4. Land cover scenarios for (a) 1850 and (b) present-day. In the 1850 scenario all present-day deciduous and evergreen forest, and urban land cover classes are converted to cropland. Average regional snow-covered surface albedo (α) estimated using MODIS relationships 2001-2005, and assumes a completely snow-covered Northeastern US.

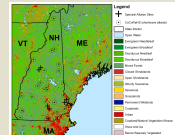
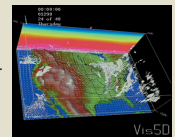


## Conclusions

1. The MODIS Terra daily 500-m snow cover and snow albedo product (MOD10A1.5) can detect differences in snow albedo over forested and non-forested land cover types.
2. Grassland, cropland, and open shrubland have significantly higher mean snow-covered surface albedo values than deciduous and mixed forest land cover types.
3. The regional-scale shift from a predominantly deforested landscape in 1850 to a predominantly reforested landscape in 2005 has resulted in a 35% decrease in winter snow-covered surface albedo.

## Future Work

1. Evaluate the Northeastern US's wintertime climate sensitivity and response to snow-covered surface albedo using the National Center for Atmospheric Research Center's Weather, Research and Forecasting model (right).
2. Surface validation of MODIS daily 500-m snow cover and surface albedo using an in-situ measurement network and aircraft measurements in the northeastern US over a wide range of land cover types.



## Acknowledgements

This research was supported by the Natural Resources and Earth System Science Fellowship and by the New Hampshire NASA Space Grant Fellowship Program.

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University of New Hampshire Graduate Research Conference  
 Durham, NH, Monday April 25<sup>th</sup>, 2011