# On the Cutting Edge

## Satellite Data Spotlights North Country Timber Harvesting Trends

*Using satellite data captured from above the earth, the Forest Society's Research Department teamed with Dartmouth College to analyze timber harvesting patterns across the North Country*

**By Dan Sundquist**

Since 1901 the Forest Society has sought to protect New Hampshire's forestland by promoting science-based forestry—which is to say, sustainable timber harvesting practices. The forest resources in the state are a critically important key to our economic and environmental health, and the Forest Society has always taught and advocated best management practices in working forests, both private and public.

In 2005 stories began to percolate out of the North Country about timber cutting occurring on a scale that recalled the liquidation practices common in the White Mountains a century ago. Concerns about the future of the North Country's forests were voiced by long-time residents, wildlife biologists, and forest managers alike.

Liquidation cutting raises a number of concerns. The forest regeneration that does occur is lower quality. It fosters erosion. Where selective harvesting often benefits wildlife by creating diverse habitat, overcutting large tracts can leave land without much habitat value. And it strips the land of any economic value other than development for decades, removing it from the active inventory of working forest. For those who care about the future of New Hampshire's forest products industry, it seemed important to understand just how widespread such cutting might be.

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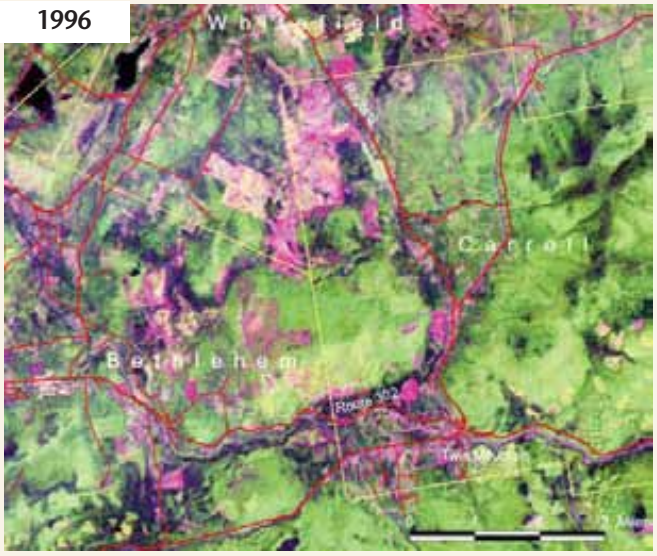
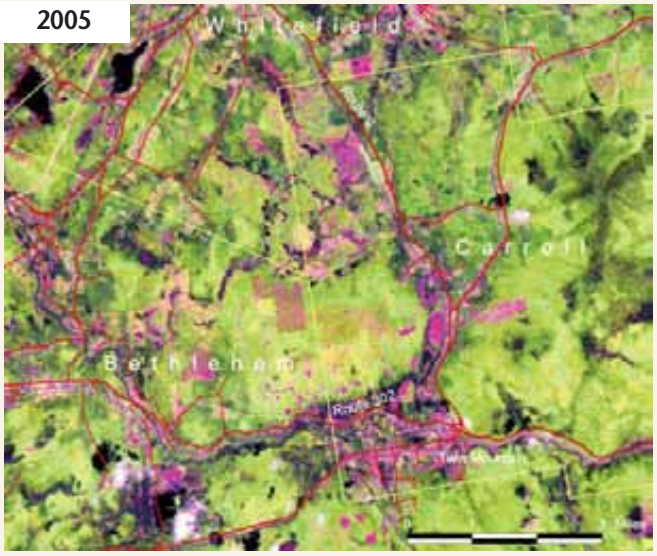
## THE SCIENCE BEHIND THE SATELLITE DATA


A large part of the science that retired Dartmouth College professor Dr. Richard Birnie contributed to this project involves the "training" of data to best reflect actual conditions on the ground. In other words, to refine what the satellite "sees" to help humans detect what is invisible to the naked eye, both in terms of patterns on the computer screen and in the statistics that ride with the data.

The satellites measure the intensity of solar radiation reflected by the earth's surface. This radiation occurs in both visible wavelengths (the colors we see in a normal air photograph) and other wavelengths not visible to the human eye (such as reflected infrared radiation). This data can be displayed in various "false color" composite images of the type pictured in this article. In addition, using sophisticated computer programs and mathematically based classification algorithms, the digital data is processed and classified on the basis of the logging activity. A critical process in the classification is "training" where the satellite data "signatures" are determined for areas of known cutting activity, and then these signatures are extrapolated across the study area to determine other cut areas.

Relying on Dartmouth's extensive library of Landsat satellite data, the remote sensing analysis initially used data spanning 18 years to establish a trendline for harvest history in the North Country divided into three time periods: 1988 to 1992, 1992 to 1999, and 1999 to 2005. These time periods made it possible to maximize cloud-free images to process and yielded the most consistent information across the region. The time frames were also chosen in order to take into consideration cutting that occurred well before and after the ice storm in 1998. Later in the project, additional data was developed for a baseline prior to 1988 in order to establish a solid baseline for the 1992 imagery.

To get an idea of how the time series can reveal the extent and distribution of harvests in a broad area, these images show cutting activity in the Whitefield area for three different time periods. The scene covers an area of about 65 square miles.

Pink indicates "predominately cleared" ground surfaces, while green and yellow colors show vegetation of various types and densities. Darker green is typically conifer forest cover. Some of the pink areas are open fields and other non-forest land cover. The Ammonusuc River can be seen along the bottom of the image.

In 1992 several small harvests are visible. Note the squarish pink areas near Route 3 and close to Whitefield.

By 1996 a large operation of more than 1,000 acres appears in the upper center of the image. Note also the reddish L-shaped harvest signature towards the center; this is an area of relatively heavy cutting, but not necessarily a liquidation cut. The small harvest sites seen in 1992 now appear as light green, indicating regeneration of young trees.

In 2005 regeneration is beginning to change the spectral image in the area of the large predominantly cleared area. Other cuts during the interim appear, including the inverted L-shaped tract near the center of the image and a fairly intensive cut to the east.

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**Figure 1.** The interest area selected for this study includes 41 municipalities covering more than 2,000 square miles of the North Country.

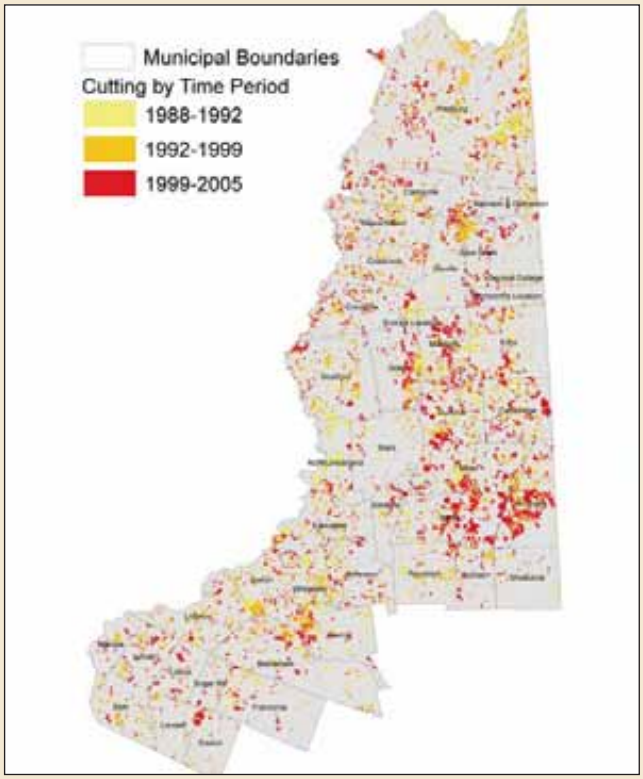


**Figure 2.** A temporal and spatial mosaic of harvest activity can be mapped for the region by merging the data developed over specific time periods.

## Launching the Research

In response to these concerns, the Forest Society embarked on a research project to get the facts. Dartmouth College, with its 27,000-acre forest property in Second College Grant and its unique perspective on North Country forestry, became a natural partner in this effort. A collaborative project emerged, with Dr. Richard Birnie, a respected scientist and former Dean of Graduate Studies and Chair of the Dept of Earth Sciences, to conduct a state-of-the-art analysis of North Country forests using a combination of remote sensing and GIS technology.

The overarching goal of the study was to assess the rate of ongoing cutting within 41 municipalities "North of the Notches" with the goal of understanding whether that cutting might be exceeding a sustainable rate of growth and replenishment in the region's forest resource base.

From the standpoint of remote sensing science, the project also had two working goals:

- Generally, to evaluate the usefulness of satellite data to identify areas of harvest operations over a period of time; and
- Specifically, to learn whether or not it would be possible to detect a range of light, moderate, and heavy cutting with reasonable accuracy.

## What the Research Shows

This study showed that by using the refined satellite imagery, a detailed cutting history can be documented over time that closely reflects the dynamic and changing year-to-year pace of actual forest change on the ground. And because the resolution of the imagery is roughly equal to a quarter acre, we can closely measure the acreage being cut over time as well.

By merging the data developed for four time periods, the time and location of cutting activity can be mapped for the region, as shown in Figure 2.

Cuttings from 1988 to 1992 are the most numerous per year, typically larger in size and evenly distributed. Cuttings from 1992 to 1999 are less numerous than the previous period but with concentrations evident in the Pittsburg/Dix's Grant area and in the southwest quarter of the study area near Whitefield and Carroll.

Finally, 1999 to 2005 cuttings increase to the highest number per year of the time periods studied and total acres operated, with a significant concentration of large operations in the southeast quarter of the study area, such as in Berlin and Success. The abundance of "predominantly cleared" areas that appeared between 1999-2005 is noticeable (the larger areas shown in red) in Success, Berlin, and Milan, and to a lesser degree, elsewhere as well.

Significant concentrations of "predominantly cleared" areas consisting of hundreds, if not thousands, of contiguous acres are often the result of liquidation cutting. Liquidation cutting is clearing the land of all merchantable trees for the purpose of making a short-term monetary gain. It is not a recognized silvicultural practice because it is not done in anticipation of improving the forest or its long-term productivity. (See related sidebar, "Silvicultural Clearcuts vs. Liquidation.")

## Digging Deeper

However, the data shows that the large-scale "predominantly cleared" areas are mostly a local phenomenon. It further shows that softwoods are being harvested at a greater rate than hardwoods, that conserved lands are experiencing less harvesting than non-conserved lands, and that high-elevation areas are being cut despite a voluntary Memorandum of Understanding meant to limit such operations.

According to a town-by-town analysis of the satellite imagery, the percentage of operable forest land cut increased significantly over the three time periods, with two municipalities exceeding an annual 2.5 percent-per-year removal rate in the 1999 to 2005 period.

Table 1 on the following page lists North Country municipalities in rank order by acres cut in the 1999 to 2005 period. If the scale of heavy cutting we currently see in Success and Berlin were true for a large part of the North Country, there clearly would be cause for concern, but the majority of municipalities are experiencing harvests that appear within the bounds of sustainability.

One measure of a sustainable rate of removal considered within the forest products industry is to harvest no more than 2.5 percent of the acres per year (on average), assuming a 40-year rotation period (frequency of harvesting) on softwood and shade-intolerant hardwood stands. (In other words, over the course of 40 years, 100 percent of a given operable area could be harvested using techniques that foster regeneration.)

The amount of operable forest land within the study area was estimated by taking the total forest land base as determined by GRANIT and backing out all land higher than 2,700 feet, all slopes steeper than 35 percent, and tax parcels smaller than five acres. GRANIT is the statewide clearinghouse for GIS data hosted by the University of New Hampshire.

GRANIT land cover data reveals that forest cover types (softwoods like spruce and fir or hardwoods like birch or maple) are being cut at different rates over time across the study area. However, those rates do not appear to be exceeding a gross sustainable harvest ratio.

Softwoods cover the least land area in the region, but are cut at the highest rate: about 57,000 acres (24 percent of total area) since 1988. Conversely, only about 25,000 acres (5 percent of total area) of hardwood cover type—which comprises about 50 percent of all forest cover in the region—has been cut since 1988. About 10 percent of mixed hardwood and softwood forest has been operated since 1988. Overall, the average annual cutting rate is about 1.25 percent, or half of the aforementioned 2.5 percent rule-of-thumb. These overall

### SILVICULTURAL CLEARCUTS VS. LIQUIDATION CUTTING

Outside of the world of forestry, the term "clearcutting" often carries a negative connotation. Like other large-scale, intensive forestry activities, the visible change that occurs with clearcutting operations may be disturbing to aesthetic sensibilities; this is understandable.

However, as a silvicultural practice, clearcutting is a time-tested method of regeneration for even-aged stands of timber by releasing seedings of desirable tree species. The goal is to create growing space to be filled promptly by a new tree crop. In New Hampshire's North Country, small-scale clearcutting and its cousins—shelterwood cuts, strip cuts, group selection harvests, and patch cuts—are among the most basic tools available to the forest manager, especially on sites where production of spruce-fir and paper birch-aspen is favorable. These methods are often used not only for regenerating forests, but also to improve the diversity of habitat for certain wildlife.

Liquidation cutting, by contrast, is not a silvicultural practice; it has no view to the future. The land is cleared of merchantable wood, and short-term gain takes precedence over long-term productivity.

There is also a difference of scale: traditional forestry prescriptions for clearcutting would be carefully calculated in proportion to the size of the area to achieve regeneration of the desired tree species often involving less than 50 acres. Liquidation cutting entails progressive operation across many hundreds of acres of forest land, potentially leading to square miles of cleared land in the space of only a few years on large land holdings.

While silvicultural clearcutting fits into a carefully planned mosaic of forestry decisions and a commitment to decades of ongoing wood flow into markets, liquidation cutting leaves a landscape with no commercial timber, devoid of diverse wildlife habitat, and with very few economically viable opportunities available to the landowner going into the future.

averages include any and all cutting, whether sustainable harvests or liquidation cuts. The higher softwood volumes during the period are not surprising, as market conditions usually drive the demand for various species of wood.

The study also examined whether cutting on public and private conservation land has been significant during any of the three time periods. Conservation easements that protect working forests often stipulate sustainable harvesting practices. The total area of protected land in the region is approximately 512,246 acres, or about 40 percent of the total land base. Of the 205,428 acres of privately-owned conservation land, only 2,820 acres, or 1.4 percent, has been cut since 1988. There are about 322,800 acres of public conservation land, of which 15,630 acres (about 5 percent) have been cut since 1988. In contrast, the total area cut on unprotected land since 1988 is about 120,900 acres, or 13 percent of private, non-conserved forest land. (The privately-owned 171,500-acre Connecticut Headwaters land, conserved in 2003, was counted as unprotected in the time period.)

Finally, in spite of voluntary agreements to limit harvesting in higher elevations, analysis of the satellite imagery revealed that significant timber cutting has been occurring above 2,700 feet in elevation over the past 20 years in some areas covered by those agreements. (See related sidebar, "Hitting the High Spots Above 2,700 Feet".)

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| Municipality | Acres Operable Forest Land* | Acres Cut 1999-2005 | Average Annual Acres Cut | Percentage of Operable Forest Base Cut | Annual Rate of Cutting |
|---|---|---|---|---|---|
| Success | 28,427 | 4,866 | 811 | 17.1% | 2.9% |
| Berlin | 31,584 | 5,012 | 835 | 15.9% | 2.6% |
| Dummer | 26,892 | 3,052 | 509 | 11.3% | 1.9% |
| Millsfield | 24,030 | 2,693 | 449 | 11.2% | 1.9% |
| Milan | 32,991 | 3,510 | 585 | 10.6% | 1.8% |
| Cambridge | 29,297 | 2,692 | 449 | 9.2% | 1.5% |
| Odell | 21,204 | 1,866 | 311 | 8.8% | 1.5% |
| Dixs Grant | 8,858 | 600 | 100 | 6.8% | 1.1% |
| Lancaster | 22,204 | 1,319 | 220 | 5.9% | 1.0% |
| Jefferson | 21,966 | 1,253 | 209 | 5.7% | 1.0% |
| Colebrook | 17,654 | 996 | 166 | 5.6% | 0.9% |
| Columbia | 28,281 | 1,550 | 258 | 5.5% | 0.9% |
| Errol | 32,826 | 1,790 | 298 | 5.5% | 0.9% |
| Lyman | 15,001 | 808 | 135 | 5.4% | 0.9% |
| Gorham | 16,045 | 861 | 144 | 5.4% | 0.9% |
| Lisbon | 12,809 | 683 | 114 | 5.3% | 0.9% |
| Clarksville | 33,976 | 1,748 | 291 | 5.1% | 0.9% |
| Carroll | 24,555 | 1,237 | 206 | 5.0% | 0.8% |
| Wentworths Location | 9,858 | 495 | 83 | 5.0% | 0.8% |
| Stewartstown | 23,786 | 1,125 | 188 | 4.7% | 0.8% |
| Dixville | 21,541 | 977 | 163 | 4.5% | 0.8% |
| Whitefield | 15,780 | 715 | 119 | 4.5% | 0.8% |
| Northumberland | 14,982 | 633 | 106 | 4.2% | 0.7% |
| Bethlehem | 37,975 | 1,542 | 257 | 4.1% | 0.7% |
| Ervings Location | 2,099 | 82 | 14 | 3.9% | 0.7% |
| Atkinson & Gilmanton | 9,726 | 369 | 62 | 3.8% | 0.6% |
| Pittsburg | 158,213 | 5,939 | 990 | 3.8% | 0.6% |
| Stratford | 36,006 | 1,234 | 206 | 3.4% | 0.6% |
| Easton | 15,730 | 532 | 89 | 3.4% | 0.6% |
| Littleton | 24,926 | 823 | 137 | 3.3% | 0.6% |
| Monroe | 10,117 | 328 | 55 | 3.2% | 0.5% |
| Dalton | 13,391 | 415 | 69 | 3.1% | 0.5% |
| Second College | 22,974 | 663 | 111 | 2.9% | 0.5% |
| Sugar Hill | 8,197 | 236 | 39 | 2.9% | 0.5% |
| Kilkenny | 7,279 | 202 | 34 | 2.8% | 0.5% |
| Franconia | 19,908 | 515 | 86 | 2.6% | 0.4% |
| Bath | 16,237 | 414 | 69 | 2.5% | 0.4% |
| Landaff | 15,420 | 325 | 54 | 2.1% | 0.4% |
| Randolph | 23,419 | 428 | 71 | 1.8% | 0.3% |
| Shelburne | 20,445 | 186 | 31 | 0.9% | 0.2% |
| Stark | 27,908 | 251 | 42 | 0.9% | 0.1% |
| **Total** | **984,517** | **58,322** | **7,123** | | |

**TABLE 1.** NORTH COUNTRY MUNICIPALITIES IN RANK ORDER BY ACRES CUT BETWEEN 1999-2005.

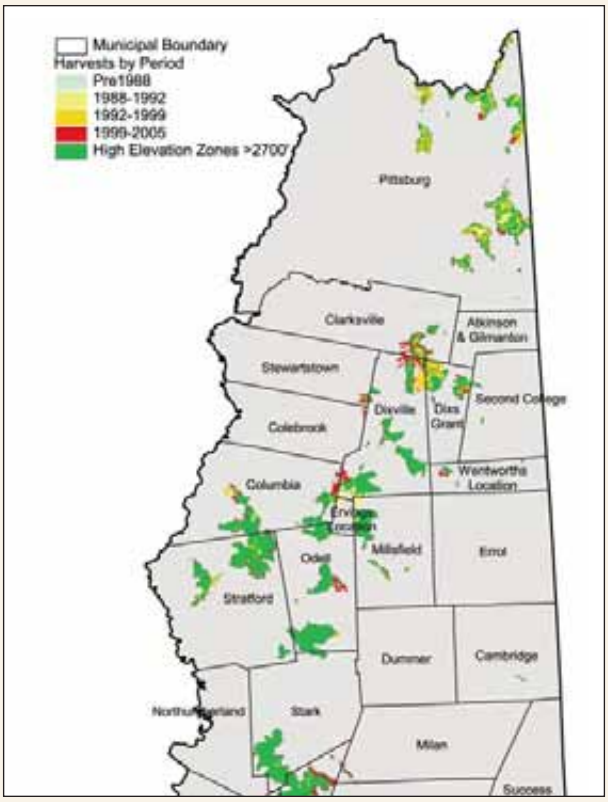
## HITTING THE HIGH SPOTS ABOVE 2,700 FEET

In spite of voluntary agreements to limit harvesting in higher elevations, analysis of the satellite imagery revealed that significant timber cutting has been occurring above 2,700 feet in elevation over the past 20 years in some areas covered by those agreements.

Generally, about 6,100 acres (27 percent of private land above 2,700 feet within the study area) have been cut heavily since 1988. More specifically, as much as 50 percent of the area in eastern Pittsburg above 2,700 feet has been left "predominantly cleared" since 1992. And in the boundary area shared by Dixville, Dix's Grant, and Clarksville, nearly 40 percent of high-elevation forests were cut since 1992.

Some, but not all, of those cuts above 2,700 feet during the time period appear to have been subject to a voluntary memorandum of understanding (MOU) between the NH Division of Forests and Lands and various individual private landowners. This MOU lays out forest management criteria to specifically protect high-elevation spruce-fir forests that are the dominant forest type due to climate and soil conditions. It is well-recognized that these forests provide essential habitat for nearly 150 wildlife species, including moose, bear, and pine marten.

Due to the sensitive character of high elevation land, the MOU spells out special forestry practices on contiguous areas above 2,700 feet. In particular, the MOU addresses access roads and skid trails, harvesting operations and methods, and maintenance of forest composition and structure in a sustainable fashion.




THE EXTENT AND DISTRIBUTION OF TIMBER CUTS IN HIGH ELEVATION SHOWN BY TIME PERIOD. THE GREEN AREAS REPRESENT LAND 2,700 FEET AND HIGHER, AS DERIVED FROM 1:100,000 SCALE TOPOGRAPHIC DATA FROM GRANIT.


THE YELLOW LINES IN THIS AERIAL PHOTO DELINEATE HIGH ELEVATION AREAS IN THE CLARKSVILLE/DIXVILLE BORDER AREA OF NORTHERN NEW HAMPSHIRE THAT WERE CUT SIGNIFICANTLY SINCE 1992.

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## Checking the Results on the Ground

The satellite image analysis proved to be a reliable method to identify areas that have been "predominately cleared" within the time periods studied.

To verify the findings, Upland Forestry of Bristol, Vermont was contracted to confirm that on-the-ground conditions matched the interpretation of the satellite data. In other words, if the satellite imagery showed a "predominantly cleared" area, was it in fact cleared of timber? And if the imagery showed extensive forest cover (no cutting) on a given area, was it in fact forested?

After obtaining landowner permission, Upland Forestry visited approximately 100 randomly selected sites, half operated and half not operated, just to be certain of both ends of the range. The final accuracy assessment returned a 94 percent accuracy rate, which is considered excellent in the field of remote sensing science.

## What the Research Doesn't Show

However, advanced work showed less success in reliably picking out cuts of moderate and low intensity. The 30-meter resolution of the satellite data is just too coarse to reliably pick up the small openings created by small patch cuts and strip cuts; selective removals just don't change the image spectrum enough to register in the remote sensing software. Higher resolution satellite data in the future may make it possible to document a full range of forestry activities.

It's also important to recognize that this study only identifies "predominantly cleared" areas. It does not definitively identify areas subject to unsustainable liquidation cuts. For example, some "predominantly cleared" areas fall within land known to have been subject to significant damage in the ice storm of 1998. Subsequent timber salvage operations on those areas could have also led to them being "predominantly cleared."

While a forester may be able to draw certain conclusions regarding the likelihood that large-scale "predominantly cleared" areas under unified ownership are a result of liquidation cuts, the study itself could draw no such definitive conclusions.

## What's Next?

Any good study should yield other questions begging to be answered, and this project is no exception. There exists now baseline data on 20 years of cutting history in the North Country that holds great potential to help forest and community planners alike as New Hampshire's northern forest resources are deployed in new directions, such as generating electricity or the production of ethanol.

**Although some of the cutting history can now be seen, remote sensing cannot look around the corner to see the future. The key question then becomes: How will society steward the region's resources to meet an unknown future?**

Based on our findings, we are left with questions such as: What is the future of the land parcels within the large-scale "predominantly cleared" areas? With all timber value removed, will these parcels be subdivided into building lots, and is that trend already underway? Is the mosaic of harvests creating a structural habitat with varied age classes that is beneficial? Which plant and wildlife species are the winners and losers? What is the effect of cutting patterns as we see them on water quality and water quantity? Are these cutting patterns significant in the context of climate change?

Finally, but very importantly, in the two years since this study was started, much has changed in terms of context. Two long-time paper mills are now quiet, and one of the paper machines in the big Rumford mill has shut down. Skyrocketing fuel costs are beginning to cause pain in the entire North Country forestry infrastructure; loggers and truckers are caught in the middle of shrinking markets and the rising cost of operations; the shrinking value of the dollar has altered the international wood markets while a housing slump is influencing demand.

Although some of the cutting history can now be seen, remote sensing cannot look around the corner to see the future. The key question then becomes: How will society steward the region's resources to meet an unknown future?

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