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Riding Winter's Trails

How snowmobiling in our region, with the help of science and sound land management, must look to the future in an era of climate change

By David Sleeper

The declining snowmobiling industry is a bellwether of climate change. No other winter sport depends so heavily on a successful combination of naturally occurring conditions on the landscape—cold air temperatures, sufficient snowfall, soil frost, ice storms, and frozen lakes and wetlands. In non-winter months, the amount of water flowing through forests also greatly affects the system of trails. All these conditions are changing rapidly and in ways that put the sport of recreational snowmobiling in peril, which would have enormous economic and societal consequences for the region.

Two recent winter seasons in New Hampshire illustrate both the importance of snowmobiling to the state's economy and the sport's startling fragility in the face of changing winter conditions. According to information compiled by Mark Okrant and Daniel Lee at Plymouth State University, in the winter of 2010-11, snowmobiling had a total economic impact to the state's economy of $586 million. These numbers included equipment sales and rentals, registration fees, food and lodging receipts, sales and gas taxes, payrolls, and more. But just a year later, with unfavorable snow conditions in the season of 2011-12, the total economic impact fell by more than half to $265 million.

Snowmobiling is big business, representing a vital ecosystem service provided by our forested landscape. It is also an essential part of our cultural heritage. People who care deeply about the activities and traditions of snowmobiling believe it is the absolute best way to enjoy nature during the cold winter months. For people with physical limitations, it may be the only way to visit the winter woods in safety and comfort. The snowmobile clubs—with their hard-working volunteers spread across the landscape—also provide essential services by creating and maintaining trails and by building ecologically sustainable bridges and drainage systems that protect water quality by avoiding erosion.

At the beginning of winter 2013-14, as part of a project supported by the National Science Foundation, the Hubbard Brook Research Foundation brought together a diverse group of 18 people from New Hampshire, Massachusetts, and Maine to discuss snowmobiling and winter climate change. Through interviews and a roundtable held in January at the USDA Forest Service's Hubbard Brook Experimental Forest in Woodstock, NH, where outside temperatures were cold but snow was only about six inches deep, we shared insights and information from our varied experiences. The group included ecosystem scientists who conduct winter forest research at Hubbard Brook; a social scientist who studies perceptions of the environment and the effects of climate change on small ski areas; state and federal land managers who interact on a regular basis with the snowmobiling community; and representatives of snowmobiling clubs and associations.

This document represents our initial attempt at a shared vision for the future of snowmobiling in an era of unprecedented climate change.

What the Science Shows

The science of winter climate change puts a grim statistical overlay on the future of snowmobiling. At the Hubbard Brook Experimental Forest, an 8,000-acre site within the White Mountain National Forest which has been intensively studied for nearly six decades, measurements of air temperatures, snow and rain, and lake ice leave no doubt about the trending winter climate. (Please note, these figures do not include results from the season of 2013-2014, a topsy-turvy year that saw low snow coverage early on, followed by heavy snows and deeply cold temperatures all the way to the onset of spring.)

- Since 1955, mean annual winter air temperatures at Hubbard Brook have increased markedly, from 20.3 degrees F to 23.9 degrees F.

- Annual maximum snow depth at one location near the Forest Service laboratory has declined by 10 inches. The number of days that snow covers the ground has decreased by 22 days. And snow disappears much earlier than in the past. In 1955, the day of last snow occurred around April 20; now it happens 10 days earlier on April 10.

- The type of precipitation falling at Hubbard Brook has changed significantly. While the average percentage of precipitation falling as rain has remained steady at about 71 percent, the amount falling as mixed precipitation (rain/sleet/snow) has doubled while the amount falling as snow has been cut in half. Today the ratio of mixed precipitation to snow is 2 to 1.

- At Mirror Lake, a 37-acre body of water where studies of ice-in and ice-out dates began in 1967, there are 33 fewer days of ice cover now than when the measurements began. While the lake tends to freeze at the same time each year during the first week of December, the ice-out date has moved inexorably earlier in the spring, from late April to early April.

Along with collecting climate data and ecological samples, Hubbard Brook scientists also conduct climate-manipulation experiments that mimic winter conditions in a warmer world, and they use sophisticated "downscaled" climate projections from general circulation models to project future trends. Together these activities constitute *basic research*—intended to produce greater understanding of how climate change affects natural processes in the forest. At Hubbard Brook, specific winter climate change studies explore, among other things, the activity of microbes in frozen soils; how much carbon trees sequester from the atmosphere under different warming conditions; and whether plant roots are damaged by freeze-thaw events, which could occur more frequently if insulating blankets of snow fail to appear.

When scientists consider how all the information they've gathered may be relevant to the human activity of snowmobiling, the prognosis isn't good. We could face a growing litany of unwelcome conditions:

- As temperatures rise, rain-on-snow events may increase in frequency, causing problems of snow retention and dangerous icing of trails.

- Freeze-thaw cycles may occur more often, causing frost heaves that make trail maintenance more difficult.

- The incidence of severe weather events such as hurricanes, ice storms, and spring flooding may be on the rise, all of which would wreak havoc on trail systems.

- Increasing snow droughts, with significant periods of no snow cover, and intermittent or patchy snowstorms may result in snow-starved areas that fragment formerly continuous regions of heavy snow cover.

All these changes to the winter landscape are expected to occur with greater variability, meaning it will become harder to predict conditions from one snowmobiling season to the next. For public land managers trying to plan and budget for the future, or snowmobilers considering investing in a new $15,000 sled, this represents a perfect storm of uncertainty.

What the Snowmobile Community Already Knows

The hard scientific numbers coming from Hubbard Brook only confirm what the snowmobiling community has suspected for years, and which it sees reflected in shorter riding seasons and declining numbers of snowmobilers. Snowmobilers who could once count on the season starting around Thanksgiving now begin riding around Christmas or well into the New Year; the overall season is often 6-8 weeks shorter than in the past. In New Hampshire's 2011-12 season, a poor snow season, registrations of snowmobiles dropped more than 50 percent from the previous year, from 56,645 to 24,936.

The snowmobile community itself is a remarkable ecosystem of human interactions, built up over many years and including snowmobile clubs, private landowners, state and federal land managers, towns and municipalities, equipment dealers and manufacturers, and chambers of commerce and other organizers of snowmobiling events. The clubs, comprising thousands of volunteers in New Hampshire and Maine, are at the heart of this web of interests.

Currently there are 7,200 miles of trails in New Hampshire and 14,000 miles in neighboring Maine; in both states, a large percentage of trails is located on private land. State agencies collect snowmobile registration fees, build vital connecting infrastructure like large bridges across rivers, and set rules for how much snow is needed for safe operation of the trails. The Forest Service builds and supervises roads and trails in the extensive White Mountain National Forest. Yet it is the private clubs that stitch the whole trail system together. Club members do the face-to-face work of interacting with landowners to secure permission for trail rights of way. And it's the volunteer club members who in most cases wield the chainsaws, cut brush, install the culverts and ditches, and operate the heavy equipment needed to keep trails in good repair. They are the ones who protect the water quality of streams with their sophisticated, well designed bridges.

Changing winter conditions are making the social interactions and economics of snowmobiling increasingly difficult. For example, money from snowmobile registration fees flows from state agencies to the clubs to help pay for expensive grooming equipment (a new groomer can cost $170,000) and for other trail maintenance costs. But if climate change leads to less snow, then snowmobile registrations drop off significantly, which means less funding available for the clubs. Thus begins a vicious negative cycle: less money for trail work, deteriorating conditions due to fallen trees and washouts, fewer club volunteers willing to work in an era of declining snow, and so on. If club memberships decline significantly, the entire trail system could come crashing down.

But don't count out snowmobilers yet. The snowmobile community has proven resilient in the face of discouraging climate news, using new technologies and land-management practices to adapt its sport to changing winter conditions. In so doing, the very nature of the sport has evolved. Chief among these changes are:

- Smoother trails – While snowmobilers can't contend with declining snowfall levels by producing artificial snow, as the downhill skiing industry does so successfully, they *can* operate with less snow. They do this by building smoother trails, removing rocks, stumps, and other obstacles that in the past might be covered by 2 feet of snow. While this practice is labor intensive, it means that riders can now operate on many trails with as little as 6-8 inches of snow on the ground when grooming begins at the start of the season (lower snow levels risk damaging expensive groomers), then with 3-4 inches or less after that.

- Better equipment and longer rides – Snowmobiles are no longer the loud, gas-guzzling machines of our grandparents' era. Today's machines are quieter and more fuel efficient, and have heated handlebar grips for keeping riders warm. The combination of better sled technologies and smoother trails—mini roads through the woods, actually—enable riders to travel longer distances. Riders may now go 100-200 miles per day, reaching the speed limit of 45 miles per hour, crossing as many as half a dozen club territories. Snowmobiles are as quiet as a car, sometimes enabling sightings of deer, moose, rabbits, turkeys, and other wildlife. As the climate changes, snowmobilers find it more difficult to just get on their snowmobiles and go. They must trailer their machines longer distances in search of consistent snow, often traveling farther north or to higher elevations.

- Better ways to deal with water – Changing winter conditions often means more water flowing across trails, causing washouts, erosion, and icing. Trail managers have responded by employing best management practices that include oversized culverts and ditching, and larger, more strongly constructed bridges. In cases where new flooding occurs because of changed stream flows, or where thawing conditions on lakes and ponds make traditional crossings that span frozen surfaces unsafe (there have been instances of snowmobilers going through the ice), trails have been re-routed.

- Instantaneous reports of trail conditions – The internet allows clubs and state agencies to update trail conditions on a daily basis, thus allowing riders to plan their trips with much greater certainty. The speed and accuracy of trail reports is a double-edged sword, however. Riders, especially from out of state, often don't purchase snowmobile licenses until hours before leaving on a trip, which can wreak havoc on a state agency's budget and ability to plan for the future.

Shared Solutions for the Future

The ultimate solution to climate change will rest on humankind's ability to reduce its carbon footprint by reducing the consumption of fossil fuels and maintaining carbon sinks in natural ecosystems. In our region, keeping forests as forests also will be an important land-use strategy in the quest to manage atmospheric carbon dioxide (see www.wildlandsandwoodlands.org) and mitigate climate change.

But we believe the snowmobiling community—acting in concert with climate scientists, public land managers, conservationists, and other motorized and non-motorized recreational users of the forest—can act proactively to protect the sport it cherishes, and in so doing raise its profile as stewards of the natural world.

We offer the following suggestions:

- First, don't squander what has already been accomplished. The existing system of snowmobile trails represents an enormous expenditure of human capital. Trails built for snowmobiles also provide other benefits for society, including access for fire protection and search-and-rescue operations. It would be a tragedy if these hard-won trails were allowed to disappear back into the forest.

- Second, work with researchers to monitor changing conditions across the landscape. Hubbard Brook scientists and others who perform long-term ecological research are eager to learn more about specific climatic conditions over time and across a regional landscape. Snowmobile clubs could provide vital data on temperature, snowfall, soil frost, and other winter conditions. Scientists, for their part, could share data and trends that are relevant to snowmobiling over 10-, 20-, and 50-year time frames. This would include working with trail managers to determine which sections of trails may be most endangered by changing winter conditions. Social scientists, too, should be part of the mix. Economists and sociologists want to know how the practices and social interactions of snowmobiling are changing, including when trail grooming starts and ends each year, the changing membership rolls of clubs (including the ages of members), and how much snowmobilers spend on their sport. A clearing house of unbiased research affecting the snowmobile industry should be established, with updated information made available to the public online.

- Third, manage trails with climate change in mind—or move them. The hard work involved in building a better, more resilient trail system reaps long-term rewards. These changes can be expensive and potentially disruptive, however, and some landowners may be reluctant to allow heavy equipment on their land to build new bridges, install properly sized ditches and culverts, or move trails altogether. Scientists could help here by offering insight during the development of best management practices and in monitoring their effectiveness. Financial incentives, including purchasing permanent or term easements, may be needed to convince landowners to accept changes to their land. Scientists should study the effects of trail building to forest ecosystems and be prepared to do public outreach in concert with snowmobiling clubs.

- Fourth, be prepared to try new models. In Maine, the Division of Parks and Public Lands is actively encouraging year-round, multi-use trails (now totaling 2,600 miles), serving both snowmobiles and the growing number of four-wheeled, all-terrain vehicles. State land managers harden these trails with stone, concrete blocks, or other durable materials and by using other best management practices specifically designed to accommodate ATV's. In the past, ATV's and snowmobiles have been like oil and water—not mixing well—and in most cases never sharing trails (ATV's are anathema to many private landowners). But the new multiple-use projects in Maine are reaping clear economic and recreational benefits. License fees from ATV users and snowmobilers can be used to fund the building and hardening of trails; thus scarce dollars can go twice as far, with each group utilizing the same trails, even in some cases (with landowner permission) at the same time of year. This will also provide recreational benefits to other trail users, including mountain bikers, dog mushers, and horseback riders. In the face of climate change, alternative economic models for snowmobiling should also be considered; snowmobile rentals, for example, as opposed to purchases, may assume a much greater role, with mobile fleets of sleds constantly searching for the best conditions.

- Fifth, conduct policymaking and planning of recreational activities with winter climate change in mind. Snowmobilers, public land managers, and policymakers must accept that climate change is here and act accordingly to protect and enhance this important recreational asset. The USDA Forest Service, for example, should include climate change, snowmobiling, and ATV riding when considering recreational uses in future Forest Plans for the White Mountain National Forest. State and federal wildlife and environmental agencies should consider how land-use regulations might be altered to encourage best management practices on trails, while continuing to protect streams and other sensitive natural resources. The non-motorized users of forestlands, especially cross country skiers and hikers, should be considered potential partners with snowmobilers and ATV users. And the scientific community must be willing to participate actively in all these discussions.

We hope and believe that the sport of snowmobiling, in conjunction with long-term ecosystem research and sound land-management practices, will remain a mainstay of this region for many years to come. Eventually a warming world may simply overwhelm the sport of snowmobiling in our region, though it's unclear if this will occur in 50 years, 100 years, or later.

In the meantime, however, a healthy, resilient, and evolving snowmobiling community can help ensure both the protection of the natural world and its enjoyment by citizens, even as climate change continues to roll slowly across the winter landscape.

David Sleeper is Executive Director of the Hubbard Brook Research Foundation (HBRF). For more information about HBRF's education, policy, and outreach programs, visit www.hubbardbrookfoundation.org. The Hubbard Brook Research Foundation's work on snowmobiling and winter climate change is supported with grants from the USDA Forest Service's Northeastern States Research Cooperative and the National Science Foundation (Award No. 0949558).

Appendix 1 / Participants in HBRF's project on snowmobiling and climate change; roundtable held at Hubbard Brook Experimental Forest, Woodstock, NH, January 28, 2014

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John Campbell
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Peter Gagne
Northern Extremes Snowmobiling, Bartlett and Bretton Woods, NH

Chris Gamache
Chief Supervisor, New Hampshire Bureau of Trails, Concord, NH

Harold Garneau
Trail Administrator, Twin Mountain Snowmobile Club, Twin Mountain, NH

Larry Gomes
Assistant Trail Administrator, White Mountain Ridge Runners, Berlin, NH

Joe Gorman
Liaison from New Hampshire Snowmobiling Association to WMNF, Alton, NH

Peter Groffman
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Ian Halm
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Larry Hamilton
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Deane Johnston
Central NH Snowmobile Club, Campton, NH

Duane Johnston
Central NH Snowmobile Club, Campton, NH

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Michael Martin
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Jon Morrissey
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Geoff Wilson
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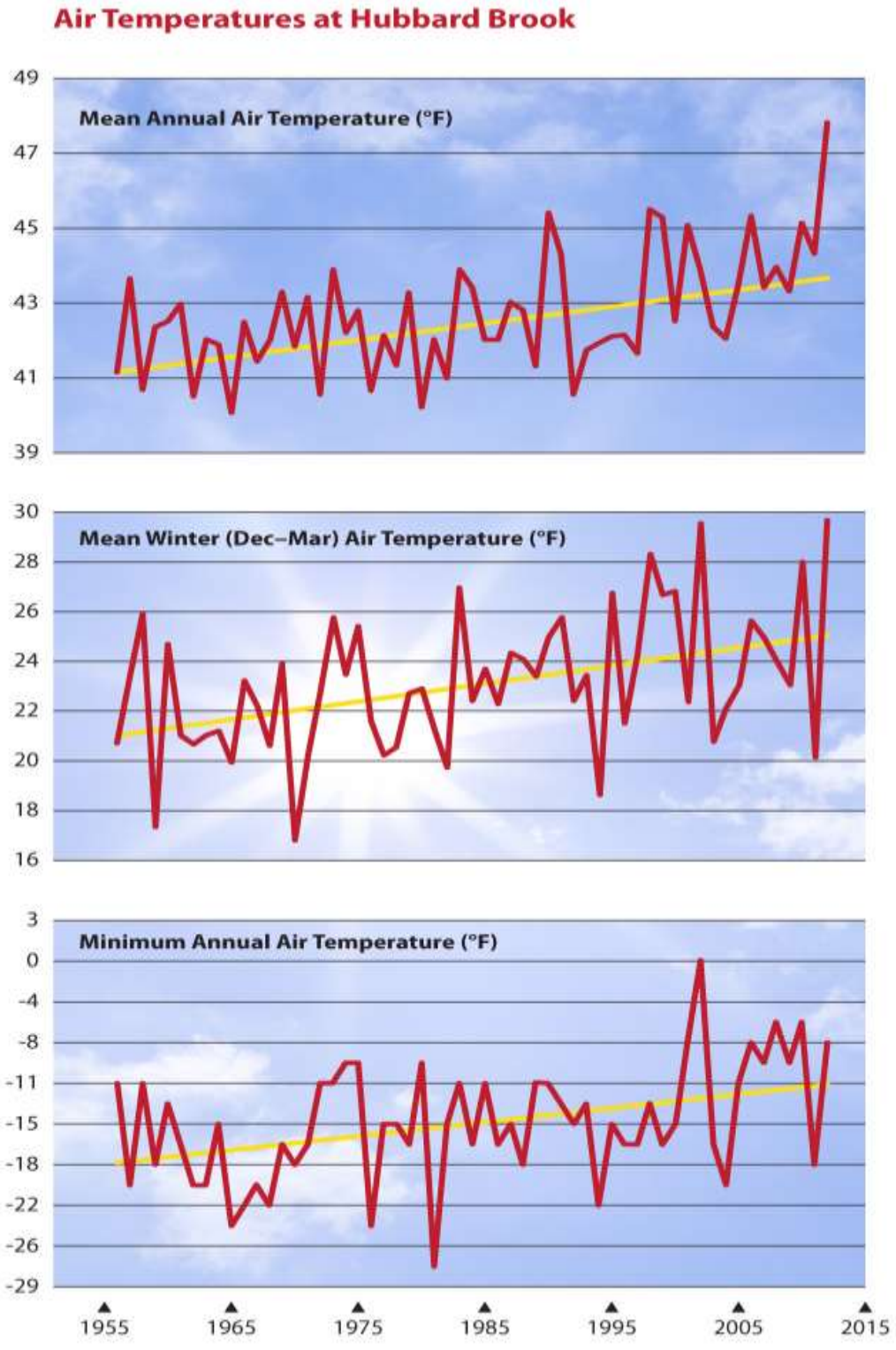
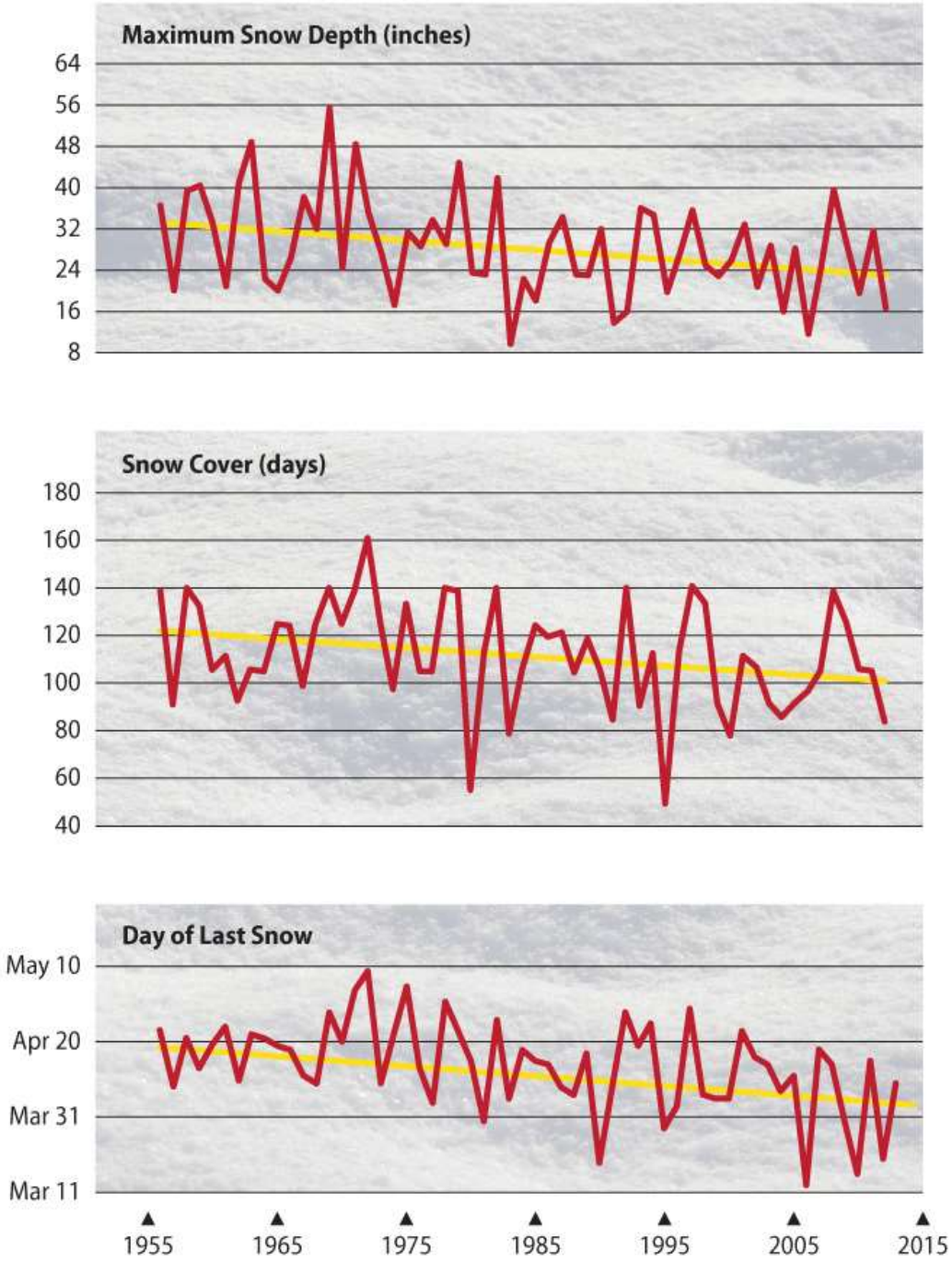
Appendix 2 / Winter-related measurements from Hubbard Brook Experimental Forest



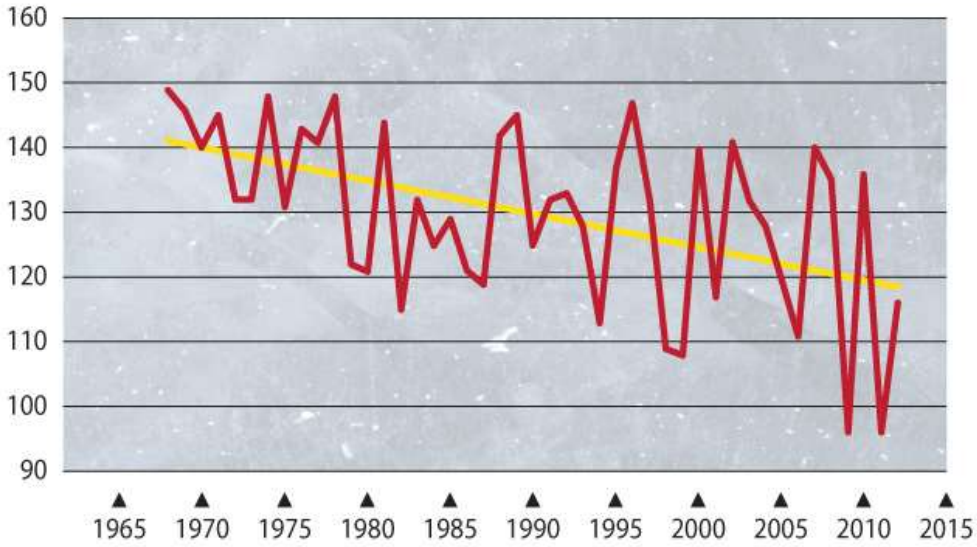
All temperatures recorded at Station 1, Hubbard Brook Experimental Forest. Courtesy USFS.

Snow Trends at Hubbard Brook



Data provided by USFS and Nina Lany.

Ice Cover on Mirror Lake (days)



Data provided by Dr. G.E. Likens NSF-LTREB.

Appendix 3 / Bibliography

Burakowski, Elizabeth and M. Magnusson. 2012. Climate impacts on the winter tourism economy in the United States. Natural Resources Defense Council (www.nrdc.org) and Protect Our Winters (www.protectourwinters.org). 33 pp.

Campbell, J.L., M.J. Mitchell, P.M. Groffman, L.M. Christenson, and J. Hardy. 2005. Winter in northeastern North America: a critical period for ecological processes. *Frontiers in Ecology*. 3(6): 314:322.

Campbell, J.L., C.T. Driscoll, C. Eagar, G.E. Likens, T.G. Siccama, C.E. Johnson, T.J. Fahey, S.P. Hamburg, R.T. Holmes, A.S. Bailey, and D.C. Buso. 2007. Long-term trends from ecosystem research at the Hubbard Brook Experimental Forest. General Technical Report NRS-17, Newtown Square, PA: U.S. Dept. Agriculture, Forest Service, Northern Research Station, 41 p.

Campbell, J.L., S.V. Ollinger, G.N. Flerchinger, H.Wicklein, K. Hayhoe, and A.S. Bailey. 2010. Past and projected future changes in snowpack and soil frost at the Hubbard Brook Experimental Forest, *Hydrological Processes*. 24: 2465-2480.

Christenson, L.M., M.J. Mitchell, P.M. Groffman, and G.M. Lovett. Winter climate change implications for decomposition in northeastern forests: comparisons of sugar maple litter with herbivore fecal inputs. 2010. *Global Change Biology*. 16: 2589-2601.

Dawson, J. and D. Scott. 2013. Managing for Climate Change in the Alpine Ski Sector. *Tourism Management*, 35: 244-254.

Dawson, J., D. Scott, and G. McBoyle. 2009. Climate change analogue analysis of ski tourism in the northeastern USA. *Climate Research*. Vol. 39: 1-9.

Frumhoff, P.C., J.J. McCarthy, J.M. Melillo, S.C. Moser, and D.J. Wuebbles. 2007. *Confronting Climate Change in the U.S. Northeast: Science, Impacts, and Solutions.* Synthesis report of the Northeast Climate Impacts Assessment (NECIA). Cambridge, MA: Union of Concerned Scientists (UCS).

Groffman, P.M., L.E. Rustad, P.H. Templer, J.L. Campbell, L.M. Christenson, N.K. Lany, A.M. Socci, M.A. Vadeboncoeur, P.G. Schaberg, G.F. Wilson, C.T. Driscoll, T.J. Fahey, M.C. Fisk, C.L. Goodale, M.B. Green, S.P. Hamburg, C.E. Johnson, M.J. Mitchell, J.L. Morse, L.H. Pardo, and N.L. Rodenhouse. 2012. Long-term integrated studies show complex and surprising effects of climate change in the northern hardwood forest. *BioScience*. Vol. 62, No., 12, 1056-1066.

Hamburg S.P., Vadeboncoeur, M.A., Richardson, A.D., and Bailey, A.S. 2013. Climate change at the ecosystem scale: A 50-year record in New Hampshire. *Climatic Change.* 116:457-477.

Hamilton, L.C. 2011. Do you believe the climate is changing? Answers from new survey research. Carsey Institute, University of New Hampshire. Issue Brief No. 40, Fall 2011.

Huntington, T.G., Hodgkins, G.A., Keim, B.D., Dudley, R.W. 2003. Changes in the proportion of precipitation occurring as snow in New England (1949-2000). *Journal of Climate*. 17: 2626-2636.

Hayhoe K., C.P. Wake, T.G. Huntington, L. Luo, M.D. Schwartz, J. Sheffield, E. Wood, B. Anderson, J. Bradbury, A. DeGaetano, T.J. Troy, and D. Wolfe. 2007. Past and future changes in climate and hydrological indicators in the US Northeast. *Climate Dynamics* 28: 381-407.

McBoyle, Geoff, D. Scott, and B. Jones. Climate change and the future of snowmobiling in non-mountainous regions of Canada. 2007. *Managing Leisure.* 12: 237-250.

Okrant, M.J. and D.S. Lee. 2011. The economic impact of spending by snowmobilers on New Hampshire's economy, 2010-11. Plymouth, NH: Plymouth State University, The Institute for New Hampshire Studies.

Okrant, M.J. and D.S. Lee. 2012. The impact of spending by snowmobilers on New Hampshire's economy during the 2011-12 winter season. Plymouth, NH: Plymouth State University, The Institute for New Hampshire Studies.

Rodenhouse, N.L, L.M. Christenson, D. Parry, and L.E. Green. Climate change effects on native fauna of northeastern forests. 2009. *Canadian Journal of Forest Research*. 39: 249-263.

Rustad, L. and J.L. Campbell, J.S. Dukes, T. Huntington, K.F. Lambert, J. Mohan, and N. Rodenhouse. 2012. Changing climate, changing forests: the impacts of climate change on forests of the northeastern United States and eastern Canada. Gen. Tech. Rep. NRS-99, USDA Forest Service, Northern Research Station, 48 p.

Seelye, K.Q. 2012. Rising temperatures threaten fundamental change for ski slopes. *The New York Times*, December 12, 2012.

Wake, C.P., E. Burakowski, and L. Gross. 2006. Winter recreation and climate variability in New Hampshire: 1984-2006. Commissioned by Clean Air – Cool Planet and The Carbon Coalition. Online at *http://www.carboncoalition.org/education/winter.php*.

Articles, white papers, and media reports that resulted from current Winter Climate Change project:

Motavalli, J. Losing winter: climate change will hit New England hard. Car Talk Blog, June 18, 2013. http://www.cartalk.com/content/losing-winter-climate-change-will-hit-new-england-hard

Schaffer, Noah, Help the mountains are melting. *Boston Phoenix*, November 7, 2012. http://thephoenix.com/Boston/life/147101-help-the-mountains-are-melting/

Sleeper, David. Protect the future of Maine snowmobiling in an era of climate change. *Bangor Daily News*, April 7, 2014. http://bangordailynews.com/2014/04/06/opinion/contributors/protect-the-future-of-maine-snowmobiling-in-an-era-of-climate-change/

Sleeper, David. Snowmobiling in an age of climate change. *Concord Monitor*. April 11, 2014. http://www.concordmonitor.com/home/11427337-95/my-turn-snowmobiling-in-an-age-of-climate-change

Sleeper, David. Riding Winter's Trails: How snowmobiling in our region, with the help of science and sound land management, must look to the future in an era of climate change. A Hubbard Brook White Paper, Hubbard Brook Research Foundation, March 28, 2014.

Sleeper, David and Pamela H. Templer. A climate change call to arms. *Boston Globe Magazine*, October 14, 2012, page 6. http://articles.boston.com/2012-10-14/magazine/34402630_1_climate-change-natural-snow-ski-area-operators

Sleeper, David and Geoff Wilson. The Changing Face of Winter: When scientists compare notes with forest users, all agree: winter isn't what it used to be. A Hubbard Brook White Paper, Hubbard Brook Research Foundation, December 13, 2012.

WBZ-TV4, CBS Boston. Researchers say New England winters getting shorter. November 21, 2012. http://boston.cbslocal.com/2012/11/21/researchers-say-new-england-winters-getting-shorter/