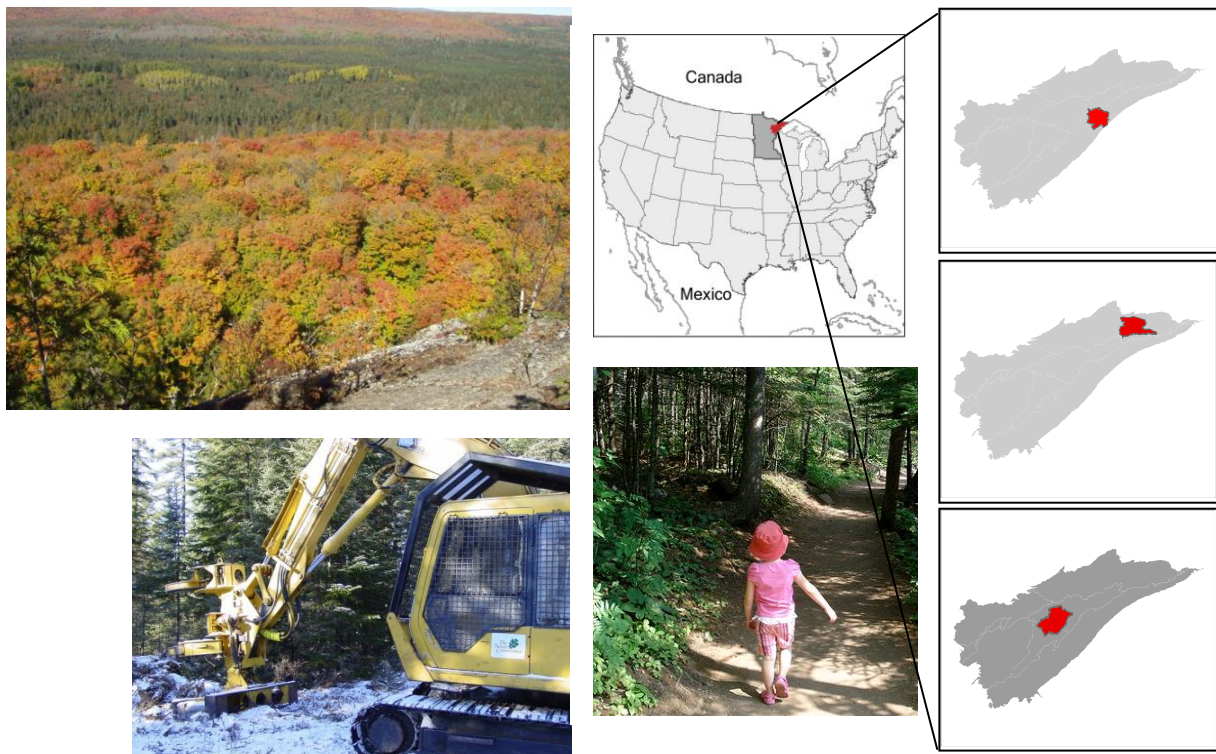


Climate Change Adaptation Case Study

Planning for the Forests of the Future: Updating Northeast Minnesota's Forest Management Strategies

2011



Minnesota's northern forest. Maps to the right highlight the three TNC focal areas of Manitou Forest, the Border Lakes and Sand Lake-Seven Beavers respectively within a larger northeast Minnesota study area (Ravenscroft et al. 2010) highlighted in grey. Photos (L to R): MN North Shore Highlands@TNC Archives, Minnesota maps@ Minnesota TNC, forest harvest@TNC Archives, trail@TNC Archives.

Case study series contact:

Katherine J. Kahl , Kimberly R. Hall, Patrick J. Doran
kkahl@tnc.org (517)316-2290
kimberly.hall@tnc.org (517)316-2257
pdoran@tnc.org (517)316-2279
The Nature Conservancy's Great Lakes Project
101 E. Grand River Ave.
Lansing, MI 48916

The Nature Conservancy in Minnesota:

Mark White and Meredith Cornett
mark_white@tnc.org (218) 727-6119
mcornett@tnc.org (218)727-6119
Northeast Minnesota Office
394 Lake Avenue South
Duluth, MN 55802

IN A NUTSHELL

The Nature Conservancy broadly defines **climate change adaptation** as the process of designing, updating and implementing strategies to account for the impacts of climate change to ensure the highest return on our conservation actions.

Our vision of “climate-smart” conservation seeks to anticipate human responses to climate change, and considers the benefits to people that result from our actions to protect and restore nature. Typical steps in creating “climate-smart” projects involve evaluating current and projected changes in climate factors, linking those changes to sensitive species, systems or processes, and ranking vulnerability. These vulnerabilities, when integrated with other stressors on the system, may lead us to change some aspect of our work to make sure highest priority threats are being addressed, and to ensure that we are investing in work with a high likelihood of providing benefits to nature and people over the long term.

This case study focuses on including climate change factors into forest management planning.

Including climate change as an additional factor in our planning allows us to make more informed ecological and financial investments on the ground. These actions ensure healthy forest systems for all who rely on forests for timber, recreation, jobs and the natural and cultural benefits they provide. Recent research findings from The Nature Conservancy in Minnesota and University of Wisconsin-Madison (Ravenscroft et al. 2010) show that forest composition in Northeast Minnesota is projected to change in the next 200 years. Loss in overall forest complexity and an increase in maple species are dominant characteristics of this projected change. Findings also show that over the long term, climate change may be working in direct opposition to current (“climate-uninformed”) restoration management actions. Forest management in Minnesota has been focused on restoring boreal species. Recent research suggests that these same species are also unlikely to survive in a changed climate. A new, “climate smart” strategy will manage for a larger diversity of tree species, allowing opportunity for the best-suited species to thrive under changed climate conditions and thus sustain an adapted future forest.

Forest managers at The Nature Conservancy in Minnesota are using these findings to update their forest management strategies for three smaller northeastern Minnesota forests. Insights from the multi-step process of linking changes in climate to likely changes in forest species, and to possible management responses, are currently helping to inform **coordinated forest management efforts across ownership and political boundaries** encompassing **four counties** and **millions of acres** in Northeast Minnesota.

The overall goal of this case study is to show how information is being used to advance conservation strategies that consider future climate threats, and to illustrate *how* and *why* climate change has been incorporated. It is intended to help The Nature Conservancy communicate how we are learning, and provide opportunities for feedback from our partners in resource protection and restoration. Through this dialog, we hope to help clarify what “adaptation” means by providing clear examples of how linking climate change impacts to the viability of our conservation targets leads us to change how we work, where we work, or the partners we engage.

THE CHALLENGE

How do we make responsible forest management decisions in ways that will benefit forest ecosystems and the people who depend on them long-term? Northern forests are valued for the

diverse and abundant timber resources they produce as well as the ecological processes they supply and support. These working landscapes generate jobs, provide recreational opportunities and spiritual benefits, protect water resources, contribute to clean air and absorb and store carbon dioxide that would otherwise be further accelerating the rate of climate change. The unique geographic position of these forests, at the climatic boundary that separates boreal and northern hardwood forests, promotes a diverse mosaic of forest types. Yet the fact that many species are at their northern or southern range limit in this region suggests these systems will be very sensitive to changes in climate.

How do we develop effective restoration techniques while also accounting for climate change? A multitude of factors are in play as forest planners work to secure the future health and productivity of forest systems. Forests are long-lived and tree species disperse slowly. Therefore changes in forest characteristics due to specific harvest regimes, restoration efforts, or changes in land use or disturbances are often realized over very large time scales. Lack of tree species diversity can put future forest establishment at risk, as projected effects of changing precipitation and temperature patterns will stress many of the currently dominant tree species. Climate change tends to exacerbate existing stresses (e.g., drought stress, pests, competition from invasive species). One way to reduce risks from these threats is to promote forest diversity both within forest stands (diversity of species), and across the landscape (diversity of forest types, and diversity of ages or conditions of forest stands so that there is variation in susceptibility to stressors like pests and fire). **The combination of a long time horizons, the desire to promote both species and structural diversity, and potential for interactions between different stressors on forests, makes identifying the “best” management approach a big challenge.**

FOREST MANAGEMENT BACKGROUND IN NORTHEAST MINNESOTA

Prior to Euro-American settlement, these systems were made up of a mosaic of boreal conifers (spruce and fir) and hardwoods (paper birch, quaking aspen) as well as north temperate species such as sugar maple, yellow birch, and white pine. Extensive logging and large slash-fueled fires, along with traditional forest management still in practice in many places today, led to reductions in the proportion of conifers on the landscape, and simplification of forest structure (e.g., more even-aged stands of trees), so restoring both the conifers and complexity has been The Nature Conservancy’s goal in this region. Traditionally, restoration goals were developed using historical (i.e., pre-European settlement) information on the “range of natural variability”, or RNV, of forest conditions. Forest planners often use a comparison between historical and current forest conditions to define and rank regional conservation targets and set objectives for desired future conditions (Landres et. al. 1999). The goal of using RNV is to recreate a more “natural” system by using management to mimic disturbance and actively work to restore species that were selectively removed in past harvests.

MINNESOTA’S FOREST MODELING APPROACH

Research Summary

A team of forest managers from The Nature Conservancy in Minnesota and forest researchers at the University of Wisconsin-Madison came together to develop and use a simulation modeling approach to help inform northern forest planning questions given climate change threats (Ravenscroft et al. 2010). They used LANDIS-II, a spatially-explicit forest ecosystem model, to examine the interaction of climate change and forest management in northeastern Minnesota (see study area on cover page). LANDIS-II simulates successional dynamics, windthrow, harvest, fire, and seed dispersal (Mladenoff et al. 1996, He et al. 1999, Mladenoff and He 1999) as well as ecosystem processes such as biomass accumulation and

decomposition (Scheller and Mladenoff 2004, Scheller et al. 2007). A shifting climate will change these dynamics and will affect forest composition. Because responses to changes in forest management unfold over long time frames (decades to hundreds of years), forest simulation modeling is often used to help visualize the costs and benefits of different management decisions

Their goal was to:

- **evaluate** whether climate-induced shifts in forest composition can be lessened through management activity and to
- **assess** the applicability of using historic forest conditions to drive current forest management objectives in the context of future climate change.

Although the historical record of forest conditions (RNV) is only a snapshot in time, it contributes to our understanding of how these systems functioned in the absence of timber harvesting, fire suppression, and other human influences. The model was purposed as a tool for managers to explore possible future forest conditions, test current management assumptions, and potentially reshape objectives given new information.

Three forest management scenarios (no harvest; current management, predominantly even-aged aspen; and a restoration-based approach) were modeled with three climate change scenarios (no change, low emissions, high emissions). Under the restoration-based management approach, harvest mimicked frequency, severity and size of distribution of historic natural disturbance regimes and attempted to increase the abundance of long-lived conifer species: Eastern white pine, red pine, white cedar and white spruce.

Given the long time lag between changes in management and changes in forest conditions, the model was run over a 100 and 200 year time period, beginning in 1995 and running through 2095, with all scenarios simulated at five-year time steps to allow for gradual change in climate. As climate projections were only available for the first 100 years, the second 100 years of the simulation were run by holding the mean temperature and precipitation values at the final 10-year (2090–2100) average.

The two future climate scenarios were based on model-averaged projections developed for the third Intergovernmental Panel on Climate Change (IPCC) report: The high emissions scenario (A2) projected a nearly 7°C increase (by 2100) in mean summer temperature, while the low emissions scenario (B2) projected a more moderate summer increase of 3.8 °C. There was not a strong contrast across scenarios in projections for precipitation, and future precipitation also did not show major changes from the control, though a greater proportion of precipitation falls as rain instead of snow in the projections. The control climate scenario was based on means for temperature and precipitation from 1971–2000.

Research Findings

Forest composition in Northeast Minnesota will likely change under future climate scenarios (Fig. 1). Specifically, there will be a shift towards more maple and a less diverse forest composition overall across the northern forested landscape. Over a 200 year period, white spruce, balsam fir and paper birch may be extirpated from the region *regardless of management activity*. Additional losses of black spruce, red pine and jack pine are also projected under the high-emission scenario. Expansion of red and sugar maple and loss of the aforementioned northerly species will substantially alter the mesic birch-aspen-spruce-fir, and jack pine-black spruce systems that are important components of the forest mosaic.

Thus, the model output suggests that many of the tree species, with the exception of white pine, that are currently under-represented on the landscape, when compared to historic conditions, are less-well suited than more southerly distributed species (maples) to a warmer climate, and are likely to be lost -

even if “restoration management” is implemented. **So, over the long term, climate change may be working in *direct opposition* to the management actions designed to achieve RNV-based goals.**

The specific species involved in the “maple-ization” effect shown under climate change scenarios were influenced by harvest activity; less shade-tolerant red maple was more prevalent in the two active management scenarios, whereas sugar maple increased in no-management scenarios. Over time the RNV-based restoration approach may lead to a loss of forest cover due to mismatches between RNV management and changed species composition due to climate. Prescriptions using large clearcuts to mimic fire for regeneration of fire-dependent species were not effective after maple species became dominant, leading to failed establishment and loss of forest cover.

The RNV management approach has benefits and limitations. As noted by Miller and Woolfenden (1999) over a decade ago, the work in Ravenscroft et al. (2010) demonstrates that rapid climate change poses serious questions to the practice of using historical data to develop management plans when we know that future climates will significantly differ from past climates. These results suggest that new approaches to forest management, that facilitate adaptation to new climates, may be needed to maintain functional forest ecosystems.

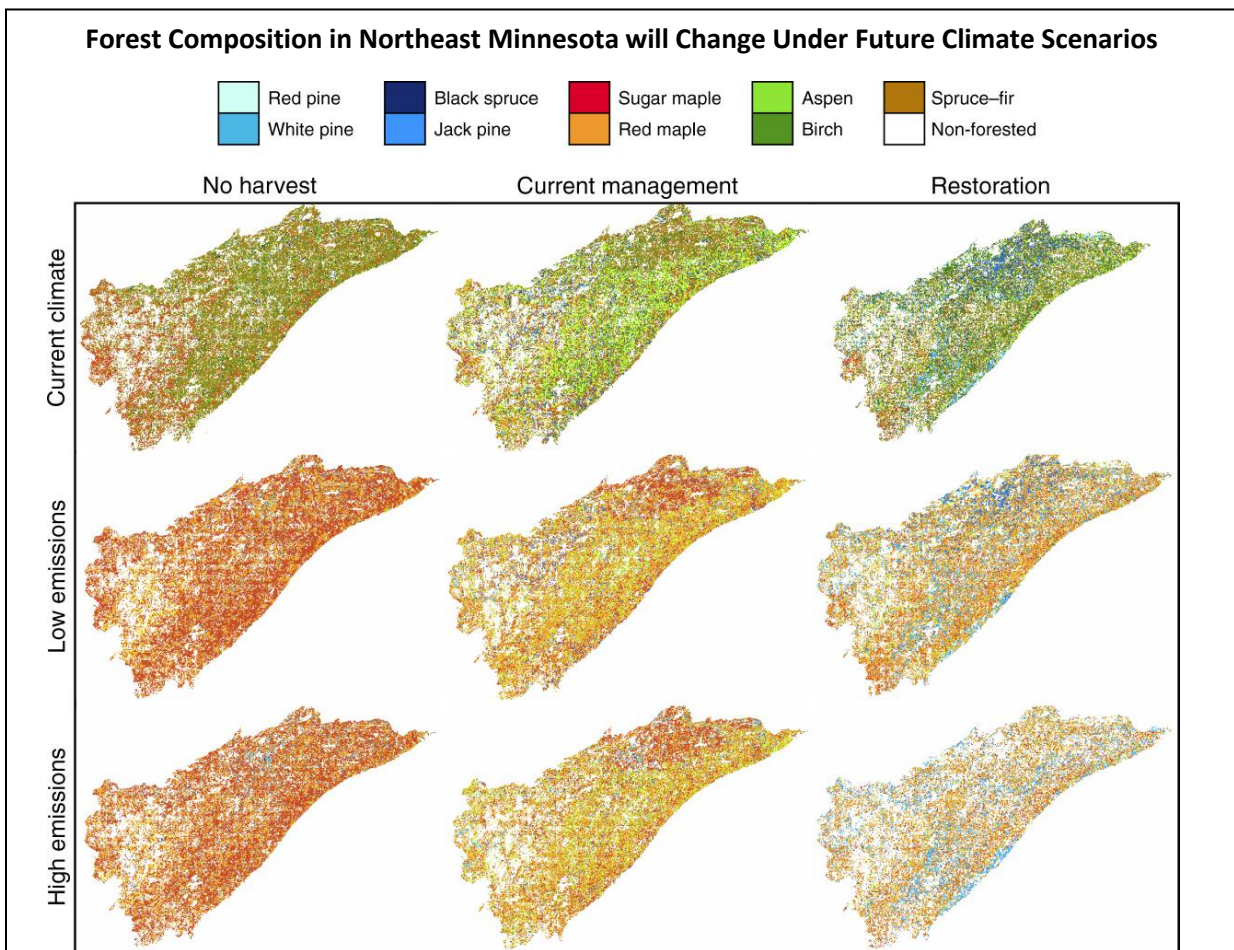


Fig. 1. Forest composition estimates for year 2195 under three harvest and three climate scenarios. Reproduced from Ravenscroft et al. 2010, by permission of the Ecological Society of America.

HOW WERE REGIONAL FINDINGS APPLIED TO SMALLER PROJECT AREAS?

The regional model (Ravenscroft et al., 2010) was used as a tool for managers to explore possible future forest conditions, test current management assumptions, and potentially reshape objectives given new information. The Nature Conservancy in Minnesota has used these regional findings as a springboard to model current and future forest system conservation targets over the next 100 years for three northeastern Minnesota forests. The forests are managed by The Conservancy and located within the larger Ravenscroft et al. (2010) study area: Manitou Forest, the Border Lakes, and Sand Lake-Seven Beavers (see cover page maps).

Model results for the three Conservancy focal areas suggest that a first step toward developing a more “climate smart” approach to managing these systems should be to update the definition of what the actions are trying to promote or conserve, (i.e., update the conservation “targets”)(Table 1). The Nature Conservancy in Minnesota is using these results to guide on-the-ground forest management recommendations that adjust objectives and strategies for conserving forest ecosystem-level targets (Table 2; adapted from Cornett et al. 2009). The new targets are a more diverse expression of current systems that will have a better chance of maintaining necessary ecosystem functions and processes in the future, while still retaining unique identities as natural communities.

Scientists from The Nature Conservancy gained new insights into the realities of reaching the aforementioned restoration goals and adjusted their focus after considering results from the forest simulation modeling, which suggested that boreal conifers would continue to decline as the climate warms. Their management objective to restore sensitive boreal species has shifted toward a goal of retaining them on the landscape rather than increasing abundance towards RNV levels (i.e., a strategy to “buy time”). **Climate-updated restoration goals will manage for a larger overall diversity of forest species rather than emphasizing increasing the boreal conifer component.** This “hedging our bets” strategy is necessary, given the uncertainty of the future climate, and further uncertainties in how both natural systems and the humans that depend on them will respond.

Table 1. Current and possible future forest system-level targets for Northeastern Minnesota. “Current Targets” represent current management and restoration goals for The Nature Conservancy. “Possible Future Targets” represent how Current Targets may change by 2095 given climate change projections (Cornett et al. 2009).

Current Targets	Possible Future Targets (2095)
Dry-mesic white pine-red pine	Dry mesic pine. (<i>predominantly white pine; red maple, quaking aspen, and white cedar also significant components</i>)
Mesic white pine-red pine	Mesic pine. (<i>predominantly white pine, with some red pine also retained; red maple, quaking aspen and white cedar also significant components</i>)
Dry-mesic jack pine-black spruce	Dry-mesic jack pine. (<i>predominantly jack pine and quaking aspen with black spruce much reduced</i>)
Mesic birch-aspen-spruce-fir	Aspen-pine. (<i>predominantly quaking aspen and white pine; spruce-fir components reduced</i>)
Northern hardwood-conifer forest	Hardwood-(conifer) forest. (<i>dominated by red maple, sugar maple, and other deciduous species with assisted migrations; some white pine and white cedar as components</i>)

Table 2. Examples of adapted conservation targets, objectives and strategies for forest composition in northeastern Minnesota forests.

Forest	2009 Forest Target	2095 Adapted Forest Targets	Adapted Forest Composition Objectives	Adapted Management Strategies
Manitou	Northern hardwood-conifer forest	Hardwood-(conifer) <i>(dominated by red maple, sugar maple, and other deciduous species; some white pine and white cedar as components)</i>	<ul style="list-style-type: none"> • Encourage structural and compositional diversity with non-maple representing at least 50% of the mix by 2095, compared to maple dominance of >65% if current management is continued. • Strive for a proportion of 10-15% white cedar by 2095 as opposed to maintaining <5% as under current management. • Maintain white spruce-fir as a significant component through 2095, as opposed to potential significant declines under current management. 	<ul style="list-style-type: none"> ○ Gap-based uneven-aged mgmt to encourage complex structure. Manage for a mix through seeding and planting; Emphasis on poorly-dispersed species. ○ Encourage structural diversity (e.g., coarse woody debris for seed beds). Protect natural regeneration from deer browse. Possible planting in areas likely to be naturally protected from deer browse. ○ Manage for full range of growth stages. Underplanting and seeding as needed.
Sand Lake Seven Beavers	Mesic birch-aspen-spruce-fir forest	Aspen-pine <i>(predominantly quaking aspen and white pine; spruce-fir components reduced)</i>	<ul style="list-style-type: none"> • Aim for quaking aspen between 10-25% through 2095 compared with aspen increasing dominance under current management to as much as 35%, thus potentially reducing resilience (around 31% in 2009). • Maintain white pine as a component (up to 10% of stems) through 2095; doubling 2009's numbers and what could otherwise be achieved through continuation of current management. • Restore white cedar to 7-10% stems by 2095, an increase of roughly 300% over 2009 levels and twice as many as would be accomplished by continuing "current" management. • Maintain white spruce-fir as a significant component though 2095, as opposed to potential significant declines under current management. 	<ul style="list-style-type: none"> ○ Shift to a greater reliance on partial harvest methods (irregular shelterwood) that maintain higher levels of canopy cover. Even-aged management as appropriate, primarily through clear-cuts of appropriate size and a 10% retention of large residual patches. ○ Surface fire; shelterwood; seeding/planting in appropriate areas. Blister rust pruning. Protection from deer browse. ○ Encourage structural diversity (e.g., coarse woody debris for seed beds). Protect natural regeneration from deer browse. Possible planting in areas likely to be naturally protected from deer browse. ○ Manage for full range of growth stages. Underplanting and seeding as needed.
Border Lakes	Jack pine-black spruce forest	Dry-mesic jack pine <i>(jack pine and quaking aspen with black spruce much reduced)</i>	<ul style="list-style-type: none"> • Maintain or slightly increase current proportion of jack pine (4-10%) through/by 2095; (currently approx. 9%), rather than populations dwindling to <3% if current management is continued. • Maintain white spruce-fir as a significant component though 2095, as opposed to potential significant declines under current management. 	<ul style="list-style-type: none"> ○ Aggressive burn program with wildfire and timber harvest; design prescribed burn to address distribution of fuel and areas of Wildland Urban Interface. Institute collaborative management in order to increase scale of prescribed fire. ○ Manage for full range of growth states. Underplanting and seeding as needed.

WAS IT WORTH IT?

Was the research- and strategy-revision worth the resources spent assessing landscape vulnerabilities to climate change threats and applying that information to focal projects in Northeast Minnesota? Did conservation objectives, strategies and targets within conservation plans change in a meaningful way? These are commonly asked questions within (and beyond) the conservation, natural resources management and planning communities.

So was it worth it? In short, yes.

This new information is being shared with regional partners across ownership and political boundaries and helping to increase overall knowledge needed to produce more robust forest management strategies. Availability of maps, visually illustrating projected forest changes, are a new and direct means of communication and are promoting dialogue with conservation partners and decision-makers.

The Northeast Minnesota Forest Resource Council's upcoming *Northeast Landscape Plan Update* (www.frc.state.mn.us/index.html) is an opportunity for diverse interests including county, state and federal foresters, Minnesota Forest Resources Council, tribes, Minnesota Deer Hunters Association and The Nature Conservancy to partner on a four-county collaborative planning effort across millions of acres that will establish the desired future condition of northeast Minnesota forests. Additionally, these groups are working with the Northwoods Climate Change Response Framework, lead by the U.S. Forest Service's Northern Institute of Applied Climate Science. They are working to ensure that climate models, research strategies and findings are being shared across northern forests in Minnesota, Wisconsin and Michigan.

The Nature Conservancy in Minnesota, with partners from Portland State University and the U.S. Forest Service Northern Institute of Applied Climate Science, has received funding for additional modeling work that will further refine the aforementioned models. They will focus on examining how the expansion of forest reserves, under different climate scenarios, may improve ecological connectivity and enhance resilience. These findings will further advance and inform regional understanding of climate vulnerability and adaptation strategies needed to ensure protection of forest systems and their value to the people who depend on them over the long term.

By including climate change factors in conservation planning, greater context has been gained for estimating the forests of the future in northeastern Minnesota – which has regional application. Insights into the ways in which forest composition may shift allows forest managers to adjust long term management prescriptions for healthier forests, a sustainable timber industry, preserved cultural value and recreation value for everyone who uses the forest. Including climate change factors does not necessarily reshape the business of conservation planning or practice in every circumstance, but it always allows us to make more informed ecological, financial and capacity investments on the ground.

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RESOURCES

Cornett, M., M. White, C. Ravenscroft, R. Scheller. 2009. Adaptation Strategies for Three Northeast Minnesota Forest Landscapes: A Second Iteration. The Nature Conservancy. (internal draft).

Daly, C., R. P. Neilson, and D. L. Phillips. 1994. A statistical–topographic model for mapping climatological precipitation over mountainous terrain. *Journal of Applied Meteorology* 33:140–158.

He, H. S., D. J. Mladenoff, and J. Boeder. 1999. An objectoriented forest landscape model and its representation of tree species. *Ecological Modelling* 119:1–19.

Landres, P. B., P. Morgan, and F. J. Swanson. 1999. Overview of the use of natural variability concepts in managing ecological systems. *Ecological Applications* 9:1179–1188.

Millar, C. I., and W. B. Woolfenden. 1999. The role of climate change in interpreting historical variability. *Ecological Applications* 9:1207–1216.

Mladenoff, D. J., G. E. Host, J. Boeder, and T. R. Crow. 1996. LANDIS: a spatial model of forest landscape disturbance, succession, and management. Pages 175–180 in M. F. Goodchild, L. T. Steyaert, B. O. Parks, C. Johnston, and S. Glendining, editors. *GIS and environmental modeling: progress and research issues*. GIS World Books, Fort Collins, Colorado, USA.

Mladenoff, D. J., and H. S. He. 1999. Design, behavior and applications of LANDIS, an object-oriented model of forest landscape disturbance and succession. Pages 124–162 in D. J. Mladenoff and W. L. Baker, editors. *Advances in spatial modeling of forest landscape change: approaches and applications*. Cambridge University Press, Cambridge, UK.

Ravenscroft, C., R. M. Scheller, D. J. Mladenoff, and M. A. White. 2010. Simulating forest restoration in a mixed ownership landscape under climate change. *Ecological Applications* 20(2): 327-346.

Scheller, R. M., and D. J. Mladenoff. 2004. A forest growth and biomass module for a landscape simulation model, LANDIS: design, validation, and application. *Ecological Modeling* 180:211–229.

Scheller, R. M., J. Domingo, B. Sturtevant, J. Williams, A. Rudy, E. Gustafson, and D. Mladenoff. 2007. Design, development, and application of LANDIS-II, a spatial landscape simulation model with flexible temporal and spatial resolution. *Ecological Modelling* 201:409–419.

White, M. and G. Host. 2000. Mapping range of natural variation in ecosystems classes for the Northern Superior Uplands: draft map and analytical methods. Natural Resources Research Institute Technical Report NRRI/TR-2000/39.