CHAPTER 4: ADAPTATION ILLUSTRATIONS

Maria Janowiak, Patricia Butler, Chris Swanston, Matt St. Pierre, and Linda Parker

In this chapter, we demonstrate how the Adaptation Workbook (Chapter 3) can be used with the Adaptation Strategies and Approaches (Chapter 2) to develop adaptation tactics for two real-world management issues. The two illustrations in this chapter are intended to provide helpful tips to managers completing the Adaptation Workbook, as well as to show how the anticipated impacts of climate change can be addressed during land management planning and activities. Additionally, connections between the resources included in this document and other sources of information, such as vulnerability assessments, are highlighted in this chapter.

About the Illustrations

We have prepared the adaptation illustrations in this chapter based on information provided from land managers on the Chequamegon-Nicolet National Forest (CNNF). In fall 2010, we collaborated with two teams, each containing four to five land managers of different specialties (such as silviculture, wildlife, and hydrology). We worked with each team to define a unique management issue of interest and held a series of meetings where the managers completed the Adaptation Workbook. The teams considered their management issue at two very different scales of management; one team worked on a forest-wide issue at the programmatic level, and the other team worked on a single project area. The illustrations below contain our interpretation of the ideas, issues, and responses that the two teams developed. In this chapter, we show how the Adaptation Workbook was used to consider climate change in forest management as a way to provide guidance for those learning to use the Adaptation Workbook (Box 12).

Box 12: Using the Illustrations

The Illustrations can:

- Provide an example of how the Adaptation Workbook was applied to a “real world” situation where climate change was considered with respect to ongoing management activities.
- Help managers understand what type of information is used in each step of the Adaptation Workbook and get a sense for the time and effort needed to complete each step.
- Present a short “case study” of how land managers are approaching adaptation in northern Wisconsin.

The Illustrations do not:

- Show the only possible ways that the Adaptation Workbook could be used to address resource management issues.
- Provide examples that will necessarily be implemented on the ground.

During the original testing of the Adaptation Workbook, the workbook contained six steps. Following the two teams' completion of the workbook, we sought the teams' comments about the efficiency and utility of the process, and how well it supported natural thought processes. Input from these discussions was later used to revise the process and condense it into five steps. For purposes of demonstration, and with consultation with the two teams, we present these illustrations as if they had originally occurred in five steps.

Illustration 1: Paper Birch Forest

For this first illustration, a team from the CNNF's Great Divide District, located in Ashland, Bayfield, and Sawyer counties, identified a project area containing paper birch that was under consideration for management within the next 5 years. In using the Adaptation Workbook, the team selected for evaluation a small subset of the project area focusing on management of early-successional aspen and paper birch because these forest types have high vulnerability to climate change and high frequency across the District. The Adaptation Workbook results for the paper birch forest type are described in this section and more information can be found in Appendix 4.

The paper birch forest type, which is dominated by paper birch and a number of boreal tree species, covers approximately 2 percent of the CNNF (Swanston et al. 2011), much of which is managed as early-successional forest for a variety of forest management and recreation opportunities (CNNF 2004). Paper birch has been identified as a tree species that is likely to experience substantial declines as a result of climate change effects and subsequent declines in suitable habitat (Swanston et al. 2011). As a result, the ability to maintain the paper birch forest type over the long term is a concern to landowners in northern Wisconsin, including the CNNF.

Step #1: DEFINE area of interest, management goals and objectives, and time frames.

The first step of the Adaptation Workbook helps define the scope for this exercise, which will be used in subsequent steps.

- The illustration team defined the **area of interest** as the paper birch forest type within a future management project with an early-successional emphasis (Table 4).
- This area of interest also defined the **location** (the project area) and **forest type** (paper birch).
- The team identified two **management goals** and several **management objectives** for the area based upon the CNNF's Forest Plan (CNNF 2004). When possible, the mature paper birch stands will be naturally regenerated to maintain paper birch forest on the landscape; in other areas that are less suitable for paper birch regeneration, a transition to white pine forest will be made to increase diversity.
- When defining **time frames**, the team identified the implementation of management as occurring in the immediate future (within 2 years). The team had some difficulty identifying a longer-term time frame, but eventually decided to use the end of the next rotation to evaluate whether management goals were realized. While defining time frames was challenging in this step, the team found the time frames helpful in completing later steps.

Table 4.—Description of the area of interest, management goals and objectives, and time frames completed in Step #1 of the Adaptation Workbook.

Area of Interest	Location	Forest Type(s)	Management Goals	Management Objectives	Time Frames
Early-successional paper birch forest within the defined project area (in Management Area 1B: Early Successional Aspen, Mixed Aspen-Conifer, and Conifer) *More information on this Management Area is available on pages 3-4 and 3-5 of the 2004 Land and Resource Management Plan (CNNF 2004).*	Paper birch stands within the project area	Paper birch	1) Retain paper birch forest on the landscape.	1) Regenerate the existing mature paper birch to retain it on the landscape when desirable.	Implementation is expected in the immediate future (2 years or less). Many management goals will be realized in the long term as paper birch is regenerated. The end of the next rotation is in ~60 years.
			2) Increase species and structural diversity.	2) Regenerate or underplant white pine among the natural paper birch when: (1) opportunities exist to improve stand diversity, (2) paper birch regeneration isn't possible, or (3) site scarification is not possible or desired.	

Step #2: ASSESS climate change impacts and vulnerabilities for the area of interest.

To evaluate the potential effects of climate change and others stressors on the area of interest, the illustration team examined a number of broad-scale impacts and vulnerabilities (see Table 3 for a complete list of broad-scale impacts and vulnerabilities by forest type) that were drawn from the *Ecosystem Vulnerability Assessment and Synthesis* (Swanston et al. 2011).

- The items in the list of **broad-scale impacts and vulnerabilities** were reviewed, and the team discussed how each of the impacts and vulnerabilities may or may not affect the area of interest that was defined in Step #1. Questions like "Is this impact important to paper birch?" or "Is this site more or less vulnerable than average?" were helpful in focusing discussion on what was most important in the area of interest.
- While the illustration team characterized potential **climate change impacts and vulnerabilities for the area of interest** using the broad-scale impacts and vulnerabilities from the *Ecosystem Vulnerability Assessment and Synthesis* (Swanston et al. 2011), team members would also have examined reports and peer-reviewed papers for additional impacts and vulnerabilities where time allowed.
- Nearly all of the impacts and vulnerabilities from the *Ecosystem Vulnerability Assessment and Synthesis* (Swanston et al. 2011) were applicable to the area of interest in some form, and about half of them were modified to better reflect those for the area of interest. For these impacts and vulnerabilities, the illustration team added text to better describe how the area of interest would be affected by climate change (Table 5). For example, the team noted that because the paper birch stands in the project area were relatively old (>60 years), the existing paper birch were more susceptible to the insects, diseases, and other disturbances that are expected to increase in the future, as well as to interactions among impacts.
- After considering climate change impacts and vulnerabilities, the team made a **vulnerability determination** that the area of interest had a "high" level of vulnerability. Current challenges to regenerating paper birch combined with projected decreases in habitat suitability and increases in a number of stressors suggested that substantial impacts to the area of interest may occur in the long term and that there may be a limited ability to buffer these impacts.

Table 5.—A portion of the assessment of impacts and vulnerabilities completed in Step #2 of the Adaptation Workbook. The items listed under "broad-scale impacts and vulnerabilities" were derived from the list in Table 3.

Broad-scale Impacts and Vulnerabilities	Climate Change Impacts and Vulnerabilities for the Area of Interest	Vulnerability Determination
	How might broad-scale impacts and vulnerabilities be affected by conditions in your area of interest? • Landscape pattern • Site location, such as topographic position or proximity to water features • Soil characteristics • Management history or current management plans • Species or structural composition • Presence of or susceptibility to pests, disease, or nonnative species that may become more problematic under future climate conditions • Other….	
Warmer temperatures	Warmer temperatures	High
Longer growing seasons	Longer growing seasons	
Altered precipitation regimes	Altered precipitation regimes	
Drier soils during summer	Warmer and drier conditions may be a substantial challenge because paper birch is on the edge of its range.	
Projected reduction in habitat suitability for many common tree species	Many tree species are projected to have reduced habitat suitability, including paper birch, aspen, balsam fir, and other common associates. Pine species are somewhat less vulnerable. Oak species may be favored.	
Increased fire and wind disturbance	Fire suppression reduces regeneration by preventing the development of required site and seedbed conditions. Regeneration of paper birch is difficult because fire cannot be used in most stands; other site preparation methods can also be constrained by visual concerns, topography, and other factors. Hotter, drier conditions may increase probability of natural fire, but it is unlikely to occur at the desired time and place.	
Increased threats from insects, diseases, and invasive plants	Because paper birch in the area of interest is over-mature, it is more susceptible to all stressors (e.g., drought, insects) and their interactions.	

Step #3: EVALUATE management objectives given projected impacts and vulnerabilities.

In this step, the illustration team evaluated climate change-related management challenges and opportunities for the area of interest.

- Many **challenges** were identified for the first objective, which focused on maintaining paper birch (Table 6). The team discussed how natural regeneration of paper birch is often difficult because heavy scarification or prescribed burning is needed to prepare a seedbed of bare mineral soil and it can be very difficult to achieve the requisite conditions. Many stands are not well-suited to the relatively high level of site preparation that is needed because of topography, accessibility, or concerns about visual impacts.
- While drier conditions and increased occurrence of wildfire could provide management **opportunities** for paper birch under certain conditions, in most cases it was expected that regeneration would become even more challenging in the future as climate change amplifies existing stressors and management challenges.
- Several management challenges and opportunities were identified for the second objective focused on species diversification using white pine because of uncertainty about future conditions.
- Given the challenges of regenerating paper birch (the first management objective), the team rated the **feasibility of meeting objective under current management** as “moderate” in the short term. In contrast, the team identified the second management objective focusing on enhancing the white pine component in selected areas as having higher feasibility than paper birch regeneration.
- The illustration team thought that the feasibility of meeting the objectives depended upon the time frame being evaluated. As a result, the team rated feasibility of meeting management objectives for both short- and long-term time frames.
- The team also identified **other considerations** which could affect its ability to achieve management objectives, including institutional, economic, social, and other non-biological constraints.

Slow down to consider…

This part of the process can be easily overlooked, but it provides a critical time to step back and verify that the management objectives and goals identified earlier are still appropriate and attainable.

- In Step #3, many challenges were identified for maintenance of paper birch, in both the short term and the long term, and long-term feasibility was rated as “low”. The team was aware of these challenges, and thought that it was very important to proceed with the existing management goal and work to sustain paper birch on the site.
- The team recognized paper birch as an important component in northern Wisconsin and that its maintenance was consistent with CNNF plans and guidelines. More importantly, because the stands in the area of interest are mature, the team noted that there is currently a small window of time available for regenerating paper birch in these stands. If no action were taken within the next few years, the paper birch in these stands would begin to die, and the forests would succeed to a later-successional forest type no longer suitable for paper birch regeneration. Lastly, because it was predicted that paper birch regeneration would become even more difficult in the future, the team observed that an opportunity existed to regenerate and establish paper birch soon (before climate change impacts increase further) in order to maintain it on the landscape for as long as possible.
- The team identified potential management challenges as well as opportunities for diversifying stands with white pine, and long-term feasibility of this management objective was ranked as “moderate”. Because feasibility was rated as “high” in the short term and “moderate” in the long term, the team

Table 6.—A portion of the evaluation of management objectives completed in Step #3 of the Adaptation Workbook.

Management Objective (from Step #1)	Challenges to Meeting Management Objective with Climate Change	Opportunities for Meeting Management Objective with Climate Change	Feasibility of Meeting Objective under Current Management	Other Considerations
Regenerate the existing mature paper birch to retain it on the landscape when desirable.	Warmer temperatures and drier conditions will make it increasingly difficult to regenerate paper birch. There is potential for more rapid decline of the species due to the northward shift in range and the expected increase in stressors. Opportunities for prescribed burns may become less available if fire danger is elevated, making site preparation more difficult to achieve.	Increased wildfire occurrence may benefit paper birch regeneration if fire occurs under the right conditions. If sites become drier, species that compete with paper birch regeneration may be reduced on some sites. Beyond this area of interest, some hardwood stands may become more conducive to paper birch management in the future as site conditions change.	Short-term: Moderate Long-term: Low	Native American tribes are interested in maintaining paper birch bark sources for baskets, canoes, and other uses. Social resistance to prescribed burning for site preparation may increase in the future, especially if wildfire occurrence increases. Additional resources and support may be needed to perpetuate the species in the future; it is unknown whether these will be available at that time.
Regenerate or underplant white pine among the natural paper birch when: (1) opportunities exist to improve stand diversity, (2) paper birch regeneration is not possible, or (3) site scarification is not possible or desired.	Regeneration of white pine (a key species identified for increasing diversity) may become more difficult due to deer browse, competition from raspberry and other plants, dry site conditions, and insect and disease outbreaks. Premature losses of the shelterwood overstory from wind disturbance may increase white pine susceptibility to white pine weevil and other pests. The white pine stock that is planted now may not be adapted to future conditions.	Regeneration of white pine may become easier if site conditions become more favorable for white pine and less favorable for competition. It may be better to regenerate white pine now because conditions in the future (50+ years) are uncertain and may be less favorable. Beyond this area of interest, some hardwood stands may become more conducive to paper birch management in the future as site conditions change.	Short-term: High Long-term: Moderate	When converting paper birch to white pine, managers need to consider the Forest Plan guidelines on species composition. White pine seedlings need to be protected from deer browse for 5-10 years after planting. When available, opportunities should be considered to diversify stands with species that may be favored in the future, such as oak species.

maintained the identified goals and objectives moving forward. Similar to the other goal, the team identified an opportunity to establish white pine in the area of interest in the near future while conditions are known to be favorable.

Step #4: IDENTIFY adaptation approaches and tactics for implementation.

To complete this step, the illustration team began by examining the Adaptation Strategies and Approaches.

- The illustration team worked through the Adaptation Strategies and Approaches chapter by discussing each **adaptation approach** individually in order. While this process took a long time, it seemed to be more efficient in the long run than taking a more "scattershot" approach. For each approach, the team discussed whether it was applicable to the area of interest and, if so, what tactics might be used to apply the approach. When an adaptation approach seemed to address management objectives and climate change challenges, the team selected it.
- For each selected approach, the team described one or more **adaptation tactics** that could be used to implement the selected approach (Table 7). Overall, the team selected 25 of the 41 adaptation approaches. Approximately 30 tactics were developed, many of which fit under more than one adaptation approach.
- Many of the tactics that were identified were consistent with existing management plans and policies. For example, the CNNF already has guidelines in place for retaining under-represented tree species in areas that are harvested. This action directly relates to one of the adaptation approaches (Maintain and restore diversity of native tree species).
- Several new tactics were also identified as ways to increase the ability of the area to adapt to new issues arising from climate change. For example, one adaptation tactic that was evaluated was to use white pine planting stock from a broader geographic area, such as southwestern Wisconsin. While current management guidelines on the CNNF recommend using seeds and seedlings from known sources and from within the climatic zone in which the planting will occur, the team recommended this tactic as one that could be considered for implementation.
- The majority of the tactics that were developed had immediate time frames because the team believed that the tactics could be implemented in the next few years along with other planned management activities.
- For each tactic, the team identified **benefits** and **drawbacks and barriers** associated with each approach. Then the team rated the **practicability** of each tactic.
- The illustration team weighed all of these considerations and selected several tactics to **recommend**. After completing the Workbook, the team will further evaluate these recommended tactics to determine whether or how these tactics will be applied.

Slow down to consider…

The illustration team identified many adaptation approaches and tactics that helped to meet their management goals and objectives and addressed the challenges that were identified in earlier steps. Therefore, they were comfortable recommending the adaptation tactics proposed for further consideration.

Table 7.—Selected adaptation tactics that were developed and evaluated in Step #4 of the Adaptation Workbook.

Adaptation Approach	Tactic	Time Frames	Benefits	Drawbacks and Barriers	Practicability of Tactic	Recommend Tactic?
Maintain or improve the ability of forests to resist pests and pathogens.	Treat selected over-mature paper birch stands with a shelterwood harvest followed by prescribed burning or mechanical site preparation. Prioritize the stands to be treated using a field check of site conditions.	Immediate (2 years or less)	Younger birch trees tend to be less vulnerable and more resilient to stressors. Addresses multiple challenges. Regenerating paper birch helps meet goals and objectives set out in the Land and Resource Management Plan.	Regeneration is not guaranteed after treatment. It is uncertain whether this approach reduces paper birch's long-term vulnerability to climate change. Success is often dependent upon site conditions.	Short-term: Moderate Long-term: Low	Yes
	On sites with an existing white pine seed source or advanced regeneration, treat selected over-mature paper birch stands with a shelterwood harvest and scarify for white pine. Underplant white pine to augment advanced regeneration if needed. Retain the overstory.	Immediate (2 years or less)	Maintains a desired forest type in stands where paper birch regeneration is not possible or desired.		High	Yes
	Adjust rotation age lengths to achieve age class distribution goals in the Land and Resource Management Plan.	Long-term (30 or more years)	Addresses the current situation, where nearly all stands are at the end of rotation age (older than 60 years). Creates diversity in age classes across the landscape, which may make stands less susceptible to some climate change impacts.	Because stands need to be regenerated very soon to maintain paper birch as a dominant species, this diversification must occur in the next rotation.	High	Yes

(Table 7 continued on next page)

Table 7 (continued).—Selected adaptation tactics that were developed and evaluated in Step #4 of the Adaptation Workbook.

Adaptation Approach	Tactic	Time Frames	Benefits	Drawbacks and Barriers	Practicability of Tactic	Recommend Tactic?
Use seeds, germplasm, and other genetic material from across a greater geographic range.	For stands where white pine is underplanted, purchase stock from inside and outside of the immediate area (e.g., from farther south, east, or west). Keep records of what was used at different locations for tracking results over time.	Immediate to short-term (10 years or less)	May introduce genotypes that are better adapted to future conditions.	Sources suited to warmer and drier conditions are limited. Some genotypes may be less adapted to current or future conditions. Current guidelines recommend using stock from within the same climatic zone.	Moderate	Yes

Step #5: MONITOR and evaluate effectiveness of implemented actions.

In this step, the illustration team selected several items to help monitor whether the adaptation tactics were effective in helping to meet the management goals and objectives, as well as whether the management objectives were being reached.

- Given the emphasis on regeneration needed to achieve the management objectives for the area of interest, many of the monitoring items focused on whether desired species were successfully retained or regenerated (Table 8). Additional monitoring items sought to determine which management tactics enhanced regeneration and long-term survival of target species.
- The illustration team discussed monitoring of both implementation (i.e., whether an action was implemented) and effectiveness (i.e., whether an action achieved its desired objective), and worked to focus on monitoring effectiveness wherever possible.
- When possible, monitoring metrics, criteria, and implementation plans used or expanded upon existing monitoring activities.
- The team made a concerted effort to utilize existing efforts for monitoring, such as scheduled field visits and routine data collection. However, the team also made suggestions for increased monitoring efforts that balanced the monitoring needs with the institutional ability to monitor.

Table 8.—Selected monitoring items that were identified in Step #5 of the Adaptation Workbook.

Monitoring Items	Monitoring Metric(s)	Criteria for Evaluation	Monitoring Implementation
Management objective 1: Regenerate the existing mature paper birch to retain it on the landscape when desirable.	Acres treated Acres regenerated	Passes stocking survey	Monitor seedling success during 3rd- and 5th-year stocking survey. If a stand fails, implement follow-up activity and update monitoring.
Management objective 2: Regenerate or underplant white pine among the natural paper birch regeneration when opportunities exist to improve stand diversity, when paper birch regeneration is not possible, or when site scarification is not possible or desired.	Acres underplanted or regenerated	Passes stocking survey	Monitor seedling success during 1st- and 3rd-year stocking survey. If a stand fails, implement follow-up activity and update monitoring.
Tactic: For stands where white pine is underplanted, purchase stock from inside and outside of the immediate area (e.g., from farther south, east, or west). Keep records of what was used at different locations for tracking results over time.	Number of trees planted from different sources or locations Number of sources used Survival rate	Short-term: Passes 1st- and 3rd-year stocking survey Long-term: follow-up survival and condition survey	Short-term: Monitor seedling success (by source or location) during 1st- and 3rd-year stocking survey. If a stand fails, implement follow-up activity and update monitoring. Long-term: Coordinate with research for long-term evaluation of stock from alternative sources or locations.

Summary: Paper Birch Forest Illustration

While the illustration team rated the area of interest as having a "high" vulnerability to climate change-related impacts, it was able to identify several adaptation tactics to help improve paper birch's resilience and work to maintain the forest type over the next rotation. At the same time, several tactics, such as those focused on tree species diversification, create opportunities for a greater range of response in the future. Many of the tactics that were identified were similar to management actions that are commonly implemented in paper birch forests, such as the retention of under-represented tree species, prevention and control of nonnative invasive species, and use of prescribed fire for site preparation when possible. Such overlap between existing practices and adaptation actions suggests that many sustainable management actions that do not directly take climate change into account can still be immensely important for responding to climate change.

Additionally, the illustration team was able to identify adaptation tactics that are new options to consider for management. These tactics included prioritizing areas of strong paper birch regeneration as future refugia, expanding the geographic area from which seedlings are obtained, underplanting stands with low densities of oak species to increase diversity, and encouraging the growth of other species when efforts to regenerate paper birch have not been successful. For these "newer" tactics, the team emphasized a greater need for both monitoring and scientific assessment to determine whether the tactics are helping to reach management goals and maintain the integrity of these forest ecosystems.

Illustration 2: Spruce Grouse Habitat Management

For this second illustration, a team from the CNNF identified a forest-wide issue rather than a specific management area. The goal of using the workbook at this level was to identify broad-scale tactics to maintain or expand the representation of suitable habitat for spruce grouse on the CNNF. Spruce grouse was chosen as a focus for this illustration because it is a rare species in the region and many of the tree species that form its habitat are projected to experience substantial declines as a result of climate change.

Spruce grouse in Wisconsin are found almost exclusively in the northern two tiers of counties (Worland et al. 2009). Surveys on the CNNF indicate that the spruce grouse are primarily found in the lowland conifer forest type, which includes the peatlands dominated by black spruce and tamarack that are preferred habitat for spruce grouse (Worland et al. 2009). The lowland conifer forest type covers 14 percent (183,465 acres) of the CNNF (Swanston et al. 2011), and the type is not actively managed except where the action would benefit or maintain habitat for species of viability concern (CNNF 2004). Additionally, a juxtaposition of upland and lowland coniferous forests is important for the spruce grouse's lifecycle needs (Gregg et al. 2004, Worland et al. 2009). Many tree species found in both the lowland and upland spruce grouse habitat, including black spruce, white spruce, tamarack, and balsam fir, are projected to have large declines in suitable habitat due to climate change effects over the next 100 years (Swanston et al. 2011). As a result, spruce grouse habitat is vulnerable and of concern to CNNF managers. The illustration team completed the Adaptation Workbook for spruce grouse habitat in five different forest types simultaneously (lowland conifer, balsam fir, jack pine, spruce, and aspen), although many of the results presented in this section focus on the lowland conifer forest type.

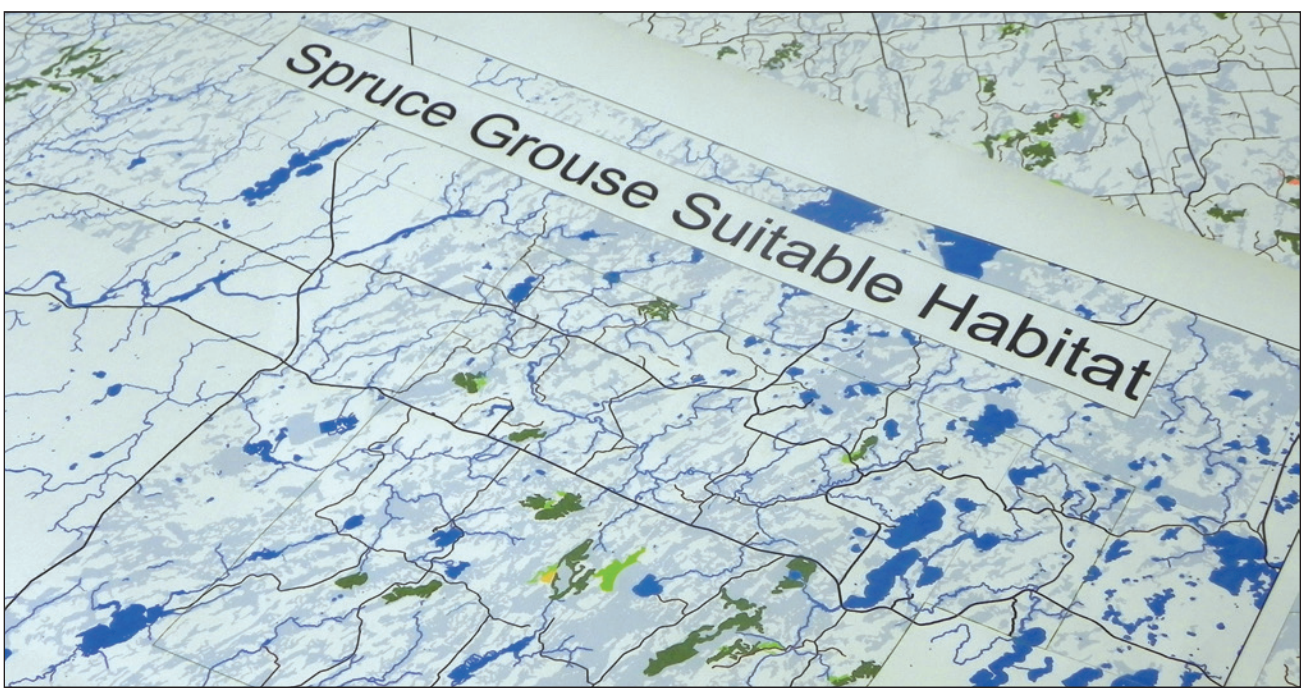

Photo by Maria K. Janowiak, U.S. Forest Service and Northern Institute of Applied Climate Science

Maps of spruce grouse suitable habitat.

Step #1: DEFINE area of interest, management goals and objectives, and time frames.

The first step of the Adaptation Workbook helps define the scope of the management topic, which will be used in subsequent steps.

- The illustration team defined the **area of interest** as all habitat potentially suitable for spruce grouse across 1.5 million acres of the Chequamegon-Nicolet National Forest (Table 9). Consistent with the Conservation Assessment for the species (Gregg et al. 2004), optimal habitat for spruce grouse consists of black spruce-dominated lowland complexes and adjacent upland areas of young short-needled conifer habitat.
- Although suitable habitat for the species exists throughout the entire Great Lakes region, the **location** was limited to spruce grouse habitat within the CNNF in order to allow for the discussion to reach the tactical level. Currently, there are no formal partnerships to manage habitat across property boundaries.
- The team identified an overarching **management goal**, which emphasized the maintenance and improvement of spruce grouse habitat at the CNNF. More specific management objectives included maintaining existing habitat as well as creating new spruce grouse habitat when opportunities exist close to current habitat.
- The illustration team had some difficulty identifying the **time frames** but ultimately suggested that the long-term maintenance of optimal habitat would occur over the next 10-100 years and the establishment of new habitat would occur in the medium term (10-15 years). While defining time frames was challenging in this step, team members found the time frames helpful in completing later steps and adjusted the time frames slightly as they progressed through the Workbook.

Table 9.—Description of the area of interest, management goals and objectives, and time frames completed in Step #1 of the Adaptation Workbook.

Area of Interest	Location	Forest Type(s)	Management Goals	Management Objectives	Time Frames
Spruce grouse habitat on the CNNF	Stands that are of sufficient size. They may occur anywhere across the CNNF.	Lowland Conifer (dominated by black spruce)	Maintain and improve habitat for spruce grouse.	1) Maintain current spruce grouse habitat where it exists on the CNNF. 2) Create new habitat for spruce grouse as opportunities arise.	Long-term maintenance of optimal habitat: 10-100 years Establishment of new habitat: 10-15 years
	Stands that are adjacent to suitable lowland conifer complexes. They may occur anywhere across the CNNF.	Jack Pine (30 years or younger)			
		Balsam Fir (30 years or younger)			
		Spruce (30 years or younger)			
		Aspen (mixed aspen-spruce-fir)			

Step #2: ASSESS climate change impacts and vulnerabilities for the area of interest.

To evaluate the potential effects of climate change and other stressors on the area of interest, the illustration team reviewed many broad-scale impacts and vulnerabilities. Table 3 contains a list of broad-scale impacts and vulnerabilities by forest type.

- The team discussed how each of the items in the list of **broad-scale impacts and vulnerabilities** may or may not affect the area of interest defined in Step #1.
- Although we provided information on impacts and vulnerabilities from the *Ecosystem Vulnerability Assessment and Synthesis* (Swanston et al. 2011), this team also relied heavily on information from the *Climate Change Tree Atlas* (Prasad et al. 2007). The team also discussed how a watershed vulnerability assessment that was in development in the area could be used to provide additional information on impacts to forested wetlands in the future. Many other sources of information could be included in this step where appropriate, especially as new information becomes available.
- In the lowland conifer forest type, nearly all of the broad-scale climate change impacts and vulnerabilities were applicable to the area of interest. The team provided more information for about a third of these impacts and vulnerabilities to better describe how climate change impacts would be amplified or buffered in the areas of interest (Table 10). For example, the team noted that the substantial decline in black spruce habitat suitability that is projected for the end of the 21st century is a critical threat to stands dominated by black spruce. Additionally, the team added two site-specific vulnerabilities to the list (e.g., drying of peatlands may result in increased fire risk).
- After considering the area's vulnerability to climate change, the team made a **vulnerability determination** that the area of interest had a "high" level of vulnerability. Projected decreases in lowland conifer habitat suitability and increases in a number of stressors suggested that substantial impacts to the area of interest may occur in the short term and long term and that there may be a limited ability for management to buffer these impacts.
- The team also noted that across the northern Wisconsin landscape, species at the extreme southern edge of their range may be more vulnerable to climatic changes. The team did not list the area as having "extremely high" vulnerability because uncertainty about projected hydrological changes prevented them from declaring that the system will be severely disrupted and unable to provide key ecosystem benefits.

Table 10.—A portion of the assessment of impacts and vulnerabilities completed in Step #2 of the Adaptation Workbook for the lowland conifer forest type. The items listed under "broad-scale impacts and vulnerabilities" were derived from the list in Table 3.

Broad-scale Impacts and Vulnerabilities	Climate Change Impacts and Vulnerabilities for the Area of Interest	Vulnerability Determination
	How might broad-scale impacts and vulnerabilities be affected by conditions in <u>your area of interest?</u> • Landscape pattern • Site location, such as topographic position or proximity to water features • Soil characteristics • Management history or current management plans • Species or structural composition • Presence of or susceptibility to pests, disease, or nonnative species that may become more problematic under future climate conditions • Other….	
Warmer temperatures	Warmer temperatures	High
Longer growing seasons	Longer growing seasons	
Altered precipitation regimes	Altered precipitation regimes	
Drier soils during summer	Drier soils during summer; increased potential for drought	
Projected reduction in habitat suitability for many common tree species	Projected reduction in habitat. Many tree species are projected to have reduced habitat suitability, including black spruce, balsam fir, and tamarack. Tamarack may be more likely to persist on some sites despite drier conditions. The Climate Change Tree Atlas projects declines in black spruce habitat of up to 90 percent by the end of the 21st century.	
Decline of associated rare species	Decline of associated rare species	
Decline of associated wildlife species	Decline of associated wildlife species, including spruce grouse	
Potential reduction in the duration of soil saturation or ponding as a result of altered hydrology and precipitation patterns	Greater likelihood that sites will dry. Lowland conifer areas may receive reduced runoff during the growing season due to higher evapotranspiration losses and lower soil saturation in adjacent upland areas.	
Increased risk of fire occurrence in dried organic soils	Increased likelihood of fire. Peatland fires are currently uncommon. Patches of this type tend to be large and have fewer roads than other types. Therefore, fires that get established may be more extensive.	

Step #3: EVALUATE management objectives given projected impacts and vulnerabilities.

In this step, the illustration team evaluated climate change-related management challenges and opportunities for the area of interest.

- Many **challenges** were identified regarding the long-term maintenance of spruce grouse habitat (Table 11). Most of these challenges are direct results of increases in temperature and decreases in water availability. Other challenges, such as increased fire risk and mortality from combined stressors, are indirect effects of climate change that could result in catastrophic loss of this forest ecosystem.
- Some **opportunities** were identified where drier conditions are suitable for other short-needled conifer species.
- The team agreed that the feasibility of establishing optimal habitat over the next 15-30 years is high because some challenges to meeting management objectives under climate change can be overcome with existing management options. Feasibility beyond 30 years is uncertain and probably much lower.
- The team also listed **other considerations**, such as spruce grouse's status as a State Threatened species, that influence the ability and priority of committing resources to achieve the management objectives. The team also concluded that the likelihood of maintaining lowland complexes in the future is low to extremely low because the challenges to meeting management objectives are probably too great to overcome on a longer time scale.

Slow down to consider…

Although this part of the process is easy to overlook, it provides the opportunity to step back and verify that the management goals and objectives identified earlier are still appropriate.

- In Step #3, many challenges were identified for maintaining spruce grouse habitat, in both the short term and the long term, and long-term feasibility was rated as "extremely low". The team was aware of these challenges, and thought that there were several reasons to continue work to maintain and create spruce grouse habitat in the short term.
- The team recognized lowland conifer species as a critical habitat component for spruce grouse and many other boreal wildlife species and noted that its maintenance was consistent with CNNF plans and guidelines. Furthermore, the presence of spruce grouse on the Regional Forester Sensitive Species List emphasized the importance of maintaining or creating spruce grouse habitat. Opportunities to integrate spruce grouse habitat management with other programs or activities may allow easier and more effective landscape-scale planning.
- The team decided that the feasibility of creating new habitat in the short term was high. Despite the low feasibility of long-term maintenance of spruce grouse habitat under current management, the team noted the importance of maintaining habitat for this State Threatened species. Acknowledging the species' status prompted the team to move forward with the management objectives it had identified and look for adaptation tactics to improve the ability to maintain spruce grouse habitat into the future.

Table 11.—A portion of the assessment of challenges and opportunities to meeting management objectives completed for the lowland conifer forest type in Step #3 of the Adaptation Workbook.

Management Objective (from Step #1)	Challenges to Meeting Management Objective with Climate Change	Opportunities for Meeting Management Objective with Climate Change	Feasibility of Meeting Objective under Current Management	Other Considerations
1) Maintain current spruce grouse habitat where it exists on the CNNF. 2) Create new habitat for spruce grouse as opportunities arise.	Decreased regeneration of black spruce and balsam fir is likely. There is potential for high mortality of mature trees due to combined stress factors. Drier conditions may increase likelihood of invasion by nonnative species. Drier conditions from altered hydrology could result in black spruce trees that are less stunted, making them usable by spruce grouse for a shorter period of time. Tree density could become reduced below levels preferred by spruce grouse. Peat fire could result in "ponding," which would make the site unsuitable for spruce grouse. Encroachment of non-preferred tree species, such as white pine, could make a stand less suitable for spruce grouse.	Predominantly open bog/peatland systems may become suitable habitat in the future as they become drier. Lowland conifer systems could gradually become suitable for other short-needled conifers, such as jack pine.	Long-term maintenance of optimal habitat: High (short term) Low to extremely low (long term) Creation of new habitat: High	Spruce grouse is a State Threatened species and Regional Forester Sensitive Species. There are legal requirements as well as CNNF policy to maintain viability of this species. Some lowland conifer in spruce grouse habitat complexes are in areas where active habitat manipulation is discouraged. This habitat is a hotspot for numerous other rare elements (e.g., orchids). Seed availability for artificial regeneration of black spruce is limited. It is at the southern edge of its range, so there is no seed source farther south.

Step #4: IDENTIFY adaptation approaches and tactics for implementation.

Given the large spatial scale that was used for this illustration, the intent was to develop adaptation actions that are applicable to a range of specific sites and conditions, while allowing for flexibility in the management decisions made at those sites.

- Because spruce grouse habitat includes many forest types across a large area, the illustration team considered all five forest types when completing this step. This exercise allowed the team to take a broader view of the landscape and think about how adaptation actions applied differently to the various forest types.
- The illustration team worked through the list of adaptation strategies and approaches by discussing each **adaptation approach** individually in order. While this was a time-consuming process, it seemed to be more efficient overall than taking a "scattershot" approach. When an adaptation approach seemed to address management objectives and climate change challenges, the team selected it and recorded any adaptation tactics that came to mind. Listing all approaches and tactics, whether they are likely to be selected or not, created a record of ideas and provided an opportunity to reconsider them later.
- The list of selected approaches was then reviewed individually to develop **adaptation tactics** to describe why and how to implement the approaches in the area of interest. For the lowland conifer forest type, the team selected 6 of the 39 adaptation approaches (and no additional approaches were created). The team identified 30 tactics across all 5 forest types, approximately 11 of which were applicable to the lowland conifer forest type.
- The majority of the tactics that were selected had immediate and short-term time frames that employ resistance approaches to improve the forest's defenses against anticipated changes. Two approaches were identified that can increase resilience or facilitate adaptation in the medium term and long term.
- The team discussed the **benefits**, as well as the **drawbacks and barriers**, for each tactic (Table 12). The team observed that uncertainty can also be evaluated in the drawbacks and barriers; some things may be uncertain now, but will likely be better understood in the future. Next, the team rated the **practicability** of the tactic. An adaptation approach is practicable if it is both feasible (i.e., it will help meet management objectives) and capable of being implemented. Adaptation tactics that are consistent with the Forest Plan are rated as having higher practicability. The team identified a number of tactics that can be implemented easily because they support the guidelines in the Forest Plan. For example, a variety of actions could be taken to manage water flow at control points to benefit lowland conifer hydrology, including road decommissioning, culvert replacement, and installation of water control structures.
- The team also identified new tactics that would require more information or greater flexibility in the Forest Plan to implement. The team acknowledged that when considering the "worst case" scenario of future conditions, extreme actions that are beyond what can currently be implemented may need to be considered. For example, if severe conditions were to cause many peatland forests to dry, it may make sense to consider artificially supplying needed water to key locations and systems.
- The team discussed the **time frames** for implementing tactics. Many can be implemented immediately to increase resilience or resistance, but several are meant to be triage responses (e.g., if hydrologic conditions become too dry some years into the future).
- The illustration team weighed all of these considerations and selected a number of tactics to **recommend**. After completing the Workbook, the team will evaluate these recommended tactics further to determine whether or how these tactics will be applied.

Table 12.—A portion of the selected approaches and devised tactics completed in Step #4 of the Adaptation Workbook

Adaptation Approach	Tactic	Time Frames	Benefits	Drawbacks and Barriers	Practicability of Tactic	Recommend Tactic?
Maintain or restore hydrology.	In lowland conifer forest type: Identify roads or other control points that affect hydrology in spruce grouse peatland complexes. Prioritize based on spruce grouse habitat qualities.	Immediate (2 years or less)	Addresses most significant challenge and other challenges. Managing wetland drainage has co-benefits of managing for wetland ecosystems, and benefits wetland ecosystem function.	Effectiveness is uncertain. Water yield manipulation could have undesirable effects on other management objectives.	Moderate	Yes
	In lowland conifer forest type: Based on prioritized list (above item), manage flow at control points to benefit hydrology. Examples include: decommissioning roads, replacing culverts, constructing berms or water control structures, and managing adjacent vegetation.	Short-term (2-10 years)	Addresses most significant challenge and other challenges. Managing wetland drainage has co-benefit of managing for wetland ecosystems and benefits wetland ecosystem function.	Effectiveness is uncertain. Water yield manipulation could have undesirable effects on other management objectives.	Moderate	Yes
	In lowland conifer forest type: Artificially supply or drain water to maintain water levels in high-priority peatlands.	Long-term (30 years or more)		Potential for many negative tradeoffs	Low	No
Maintain and create habitat corridors through reforestation or restoration.	Across all forest types: As part of the proposed Spruce Grouse Habitat Assessment, evaluate current level of connectivity between suitable spruce grouse habitat complexes. Map or identify current or potential corridors.	Long-term (30 or more years)	May allow for spruce grouse to disperse to currently unoccupied habitat or habitat that becomes suitable in the future.	Corridors can also serve invasive species, predators, and other undesirable species. May not be consistent with other landscape management objectives. Is suitable only in limited areas.	Moderate	Yes

Slow down to consider…

The illustration team identified a number of adaptation approaches and tactics to help meet its management objectives and address the challenges that were identified in earlier steps. Despite having identified only a few approaches and strategies that help meet management objectives in the long term, the team has considered and developed responses to substantial challenges in maintaining spruce grouse habitat.

Step #5: MONITOR and evaluate effectiveness of implemented actions.

In this step, the illustration team selected several items to help monitor whether the adaptation tactics were effective in helping to meet the management objectives, as well as whether the management goals and objectives were being reached (Table 13).

- Given the landscape-level focus of the management objectives for the area of interest, many of the **monitoring items** addressed whether spruce grouse were utilizing areas of potential habitat, and whether landscape planning for the spruce grouse was being integrated into project planning and management.
- When possible, **monitoring metrics, criteria, and implementatio**n plans used or expanded upon existing monitoring activities, such as tree stocking surveys.
- Monitoring is important in gathering data about the greatest uncertainties for spruce grouse habitat management. For example, current models are not able to predict tree species' responses in cooler sites or in other microenvironments. Monitoring will be valuable in determining where important tree species are more likely to persist and which management actions are helping to adapt ecosystems to climatic changes.
- The illustration team discussed two types of monitoring. One type focused on whether an action was implemented, such as whether recommended tactics were incorporated into the design criteria of a project. Another type looked more directly at whether an action was effective in meeting its desired objective. For example, while this illustration focused on maintaining spruce grouse habitat, the team recognized that it is important to monitor actual birds to evaluate whether they are using the habitat.

Table 13.—A portion of the selected monitoring metrics completed in Step #5 of the Adaptation Workbook.

Monitoring Items	Monitoring Metric(s)	Criteria for Evaluation	Monitoring Implementation
In lowland conifer forest type: Identify roads or other control points that affect hydrology in spruce grouse peatland complexes. Prioritize based on spruce grouse habitat qualities.	Monitor implementation: determine if complete.	Were control points and roads in all priority spruce grouse habitat complexes identified?	Check after 5 years.
In lowland conifer forest type: Identify roads or other control points that affect hydrology in spruce grouse peatland complexes. Prioritize based on spruce grouse habitat qualities.	Monitor effectiveness: metrics to be determined after consultation with a hydrologist.	Criteria to be determined after consultation with a hydrologist	Implementation to be determined after consultation with a hydrologist.
Across all forest types: As part of the proposed Spruce Grouse Habitat Assessment, evaluate current level of connectivity between suitable spruce grouse habitat complexes. Map or identify current or potential corridors.	Monitor implementation: determine if complete.	Was a Spruce Grouse Habitat Assessment completed?	Check annually for completion.
Across all forest types: Connect large lowland conifer peatland complexes with suitable upland habitat to allow spruce grouse dispersal to currently unoccupied habitat. For example, convert key stands to short-needled conifer types to increase connectivity between spruce grouse habitat complexes.	Monitor implementation: determine whether activities to encourage or convert to short-needled conifer are occurring in identified “key stands”.	Presence of activity in key stands to encourage or convert to short-needled conifer	Review prescriptions and other documents within the identified key stands.
	Monitor effectiveness: assess usage by spruce grouse in connector stands.	Occurrence of spruce grouse in key stands	Conduct spruce grouse surveys.

Summary: Spruce Grouse Habitat Management Illustration

This team identified five forest types that were important for spruce grouse habitat across the landscape, which centered on lowland conifer complexes. Although this illustration has emphasized the discussions on lowland conifer systems, all forest types were considered simultaneously because of their relationships with each other and how spruce grouse populations might find them desirable.

The vulnerabilities, tactics, and monitoring items identified by the team in the Adaptation Workbook have the potential to be incorporated into future management direction on spruce grouse habitat on the CNNF. Additionally, several of the approaches and tactics identified during this process may be useful to managers considering actions to maintain spruce grouse habitat.