2021

Forest Policies and Adaptation to Climate Change in Maine: Stakeholder Perceptions and Recommendations

Alyssa R. Soucy
University of Maine, Orono, alyssa.r.soucy@maine.edu

Sandra De Urioste-Stone
University of Maine, Orono, sandra.de@maine.edu

Ivan J. Fernandez
University of Maine, Orono, ivanjf@maine.edu

Aaron Weiskittel
University of Maine, Orono, aaron.weiskittel@maine.edu

Parinaz Rahimzadeh-Bajgiran
University of Maine, Orono, parinaz.rahimzadeh@maine.edu

See next page for additional authors

Follow this and additional works at: https://digitalcommons.library.umaine.edu/mpr

Part of the Environmental Studies Commons, Forest Management Commons, Natural Resources Management and Policy Commons, Social Psychology Commons, and the Social Statistics Commons

Forest Policies and Adaptation to Climate Change in Maine: Stakeholder Perceptions and Recommendations

Authors

Alyssa R. Soucy, Sandra De Urioste-Stone, Ivan J. Fernandez, Aaron Weiskittel, Parinaz Rahimzadeh-Bajgiran, and Tom Doak

Forest Policies and Adaptation to Climate Change in Maine:

Stakeholder Perceptions and Recommendations

by Alyssa R. Soucy, Sandra De Urioste-Stone, Ivan J. Fernandez, Aaron Weiskittel, Parinaz Rahimzadeh-Bajgiran, and Tom Doak

Abstract

Socioeconomic pressures require forest management to address the impacts of climate change. However, we must ask, Are current forest policies sufficient to deal with the impacts of climate change? Here, we report on two surveys of forest stakeholders in Maine including woodlot owners and forestry professionals and discuss their perceptions of the barriers to climate change adaptation. We conclude with several policy directions including reevaluating existing policies, expanding incentive-based policies, integrating adaptation efforts into mitigation efforts, and increasing communication and outreach.

BACKGROUND

Maine's forests are well known for their ecosystem services including recreational opportunities, productive timberland, water quality, cultural value, carbon sequestration, and wildlife habitat. Given the vital role they play in many facets of Maine life, forests have been an integral part of the state's identity. As the most forested state in the country, Maine communities are also heavily reliant on natural resources for their economic and social well-being. Over the past century, Maine's forests have undergone significant changes in land ownership, with forestland control transitioning from industrial landowners to investment firms, developers, and conservation groups (Irland 2005). Alongside these tenure and management shifts, there have also been changes in the natural environment due in part to a changing climate (Fernandez et al. 2020). Extreme rainfall events, warmer winters, increased tree mortality due to insects and disease, and changes in the types of species that can naturally regenerate are just some of the challenges already affecting Maine's forests (Janowiak et al. 2018).

The impacts of climate change on forest ecosystems and the forest industry coupled with historical changes in forest-land ownership raise concerns over the future sustainability and health of forests in the state (Fernandez et al. 2020; Jin and Sader 2006). Given the multiple environmental, social, and economic pressures Maine's forest industry faces, there is a need to accommodate emerging market opportunities while addressing challenges (MacDonald et al. 2018). For example, while new innovations and technologies emerge, the industry will also have to ensure they have a prepared workforce that can capitalize on changing markets (FOR/Maine 2018). In considering the importance of management decisions that may ultimately ensure the future of forest ecosystems and the forest industry, the question naturally arises, Are current forest practices and policies sufficient to deal with the impacts of climate change?

Resilient forest management in Maine will require an enhanced capacity for the forest industry's social and ecological systems to respond to change. While adaptation has only recently emerged as a strategy and policy concern (Schipper 2006), it is becoming increasingly clear that adaptation efforts must complement mitigation efforts to respond to climate change. Adaptation involves anticipating, preparing for, and responding to challenges and opportunities presented by climate change, while mitigation refers to reducing greenhouse gases or increasing the uptake of carbon that may limit global warming (IPCC 2021). Adaptation, for example, may look like increasing the diversity of tree species and age classes within a forest, diversifying forest products, improving roads and culverts to

address extreme weather events, or monitoring and removing invasive species, pests, and pathogens.

Adapting to climate change brings with it scientific, operational, and policy challenges that landowners must balance while considering the tradeoffs of enrolling in tax programs, developing management plans, and investing in adaptation efforts (Irland 2020). The impacts of climate change are experienced differently across the state and interact in complex ways. Therefore, it can be difficult to develop and implement appropriate adaptation measures (Spittlehouse 2005). Sustainable forest management may require novel practices and policy instruments to protect critical ecosystems, preserve Maine's forests for future generations, and sustain the broader forest industry (Judd 2020).

Maine's current policies and programs include regulations (e.g., Forest Practices Act), a statewide forest inventory and monitoring program, tax incentives (e.g., Tree Growth program), and educational programs (e.g., via Maine Forest Service). Within Maine, there are currently no regulations or policies that explicitly encourage climate change adaptation related to forest management; instead, adoption of adaptation strategies rests with individual landowners and companies. This lack, however, may change with the release of Maine's climate action plan (December 2020) and the Governor's Forest Carbon Task Force report (September 2021), which both outlined recommendations for technical and financial incentives for forest management, including voluntary programs to increase carbon storage, promote bioproduct innovation, and encourage the adoption of climate-friendly practices. There are also a variety of organizations developing forest management strategies to assist landowners in making decisions, including Manomet, the Cooperative Forestry Research Unit at the University of Maine, the US Department of Agriculture, and the Maine Forest Service among others. In an effort to build capacity for decision-making and climate change adaptation, these organizations conduct workshops, networking opportunities, and provide menus of adaptation options for landowner support. While adaptation menus provide options for land managers and landowners to choose from to address climate change impacts, there are varied levels of implementation of adaptation strategies among forest stakeholders (Sousa-Silva et al. 2016).

Understanding barriers to adaptation is a first step to increasing widespread adoption. Specifically, barriers such as lack of knowledge or access to information, lack of technology, financial constraints, perceptions of uncertainty, and insufficient personnel may limit the adoption of climate change adaptation measures (Vulturius and Swartling 2015). In addition, a variety of social and cultural factors may also influence whether or not adaptation strategies are implemented by forest managers; these can include social or organizational norms that may limit or encourage the implementation of adaptation strategies. In other words, if an individual's close friends, family, or coworkers believe in the importance of adaptation actions, that individual may feel pressure to implement those actions as well. Perceptions of the level of risk climate change poses to forest ecosystems and operations, cultural values regarding views for protecting the environment, and beliefs surrounding the causes and consequences of climate change can also influence adaptation implementation.

Addressing barriers to increased climate change adaptation involves communicating and engaging with stakeholders. In addition, it may also require state and federal efforts to break down existing institutional and resource barriers such as a lack of financial support or policies that restrict sustainable practices. Given the uncertainties involved in managing for future climate changes, along with the associated upfront costs of some adaptation efforts, a lack of policy incentives may be negatively affecting the landowners' willingness to implement adaptation strategies (Hotte et al. 2016). The purpose of this paper is to explore current perceptions of Maine's forest policies and practices in light of climate change with a focus on specific barriers to climate change adaptation and potential incentives. We primarily focus on adaptation although we will discuss linkages where adaptation can overlap and complement larger mitigation efforts.

METHODS

We conducted two online surveys of Maine forest stakeholder groups, Maine's Woodland Owners Association (MWO) and University of Maine's Cooperative Forestry Research Unit (CFRU).[1] We define stakeholders as landowners who play a role in managing forest holdings and therefore have a high degree of interest in, and would be influenced by, forest policy in the state (Reed et al. 2009). We sampled members of these two organizations rather than drawing from all woodlot owners; therefore, the participants may be more aware of assistance programs

and policies due to their affiliations. The first survey was completed by 211 forest stakeholders in the fall of 2019. The survey asked respondents about their perceptions of climate change, as well as barriers to and incentives for adaptation (Soucy et al. 2020). Lingering questions regarding perceptions of Maine's forest policies resulted in a second online questionnaire in the fall of 2020, which was completed by 82 forest stakeholders. We asked respondents about specific forest practices and policies and their perceptions of climate change information.

MWO is a group of over 2,000 small private woodland owners whose goal is to promote stewardship in forest management and support woodland owners in the state. CFRU is a group of more than 500 foresters and land managers from the forest products industry, government, nongovernmental organizations, state agencies, and research. Hereafter, we will refer to the two groups as small woodlot owners and forestry professionals, respectively. We acknowledge that overlap does exist between the two groups and they are not mutually exclusive; however, the characterization is an attempt to distinguish between two stakeholders groups that, while similar, are composed of members with mostly differing objectives and operation sizes. We present results from the combination of both stakeholder groups when there are no significant differences in opinions, and separate results for the two stakeholder groups when significant differences exist.

RESULTS

Of the 211 respondents for the first survey, 54 percent were small woodlot owners, and 46 percent were forestry professionals. Of the 82 respondents for the second survey, 56 percent were small woodlot owners, and 44 percent were forestry professionals. Across both surveys, we found a diversity of stakeholders managing or owning a range of land sizes and having a broad range of experiences (Table 1a, b).

Perceptions of Climate Change Practices and Policies

Approximately half of forest stakeholders agreed that Maine needs to adopt new policies and forest management practices to deal with the impacts of climate change (Figure 1). Small woodlot owners more strongly believed in the need for new forest practices and forest policies compared with forestry professionals, suggesting that the former may

TABLE 1A: **Characteristics of Survey 1 Respondents**

Participant profile	Survey 1 (N=211) (%)
Years of experience	
5 and less	17.7
6–10	9.7
11–20	20.8
21–40	32.7
41 and over	16.8
Number of employees within company/organization	
1	33.8
2–10	18.2
11–25	8.4
25–60	8.4
60 and over	12.3
Association/stakeholder group	
Forestry professional	46.0
Small woodlot owner	54.0

TABLE 1B: **Characteristics of Survey 2 Respondents**

Participant profile	Survey 2 (N=82) (%)
Years of experience	
5 and less	12.3
6–10	5.3
11–20	28.1
21–40	29.8
41 and over	24.6
Acres of land managed or owned	
Less than 50	21.4
51–100	10.7
101–500	23.2
501–1,000	10.7
1,000–500,000	12.5
500,000–1 million	8.9
Greater than 1 million	12.5
Association/stakeholder group	
Forestry professional	44.4
Small woodlot owner	55.6

FIGURE 1: Perceptions of Maine's Forest Policies and Practices Dealing with Impacts of Climate Change (n=187)
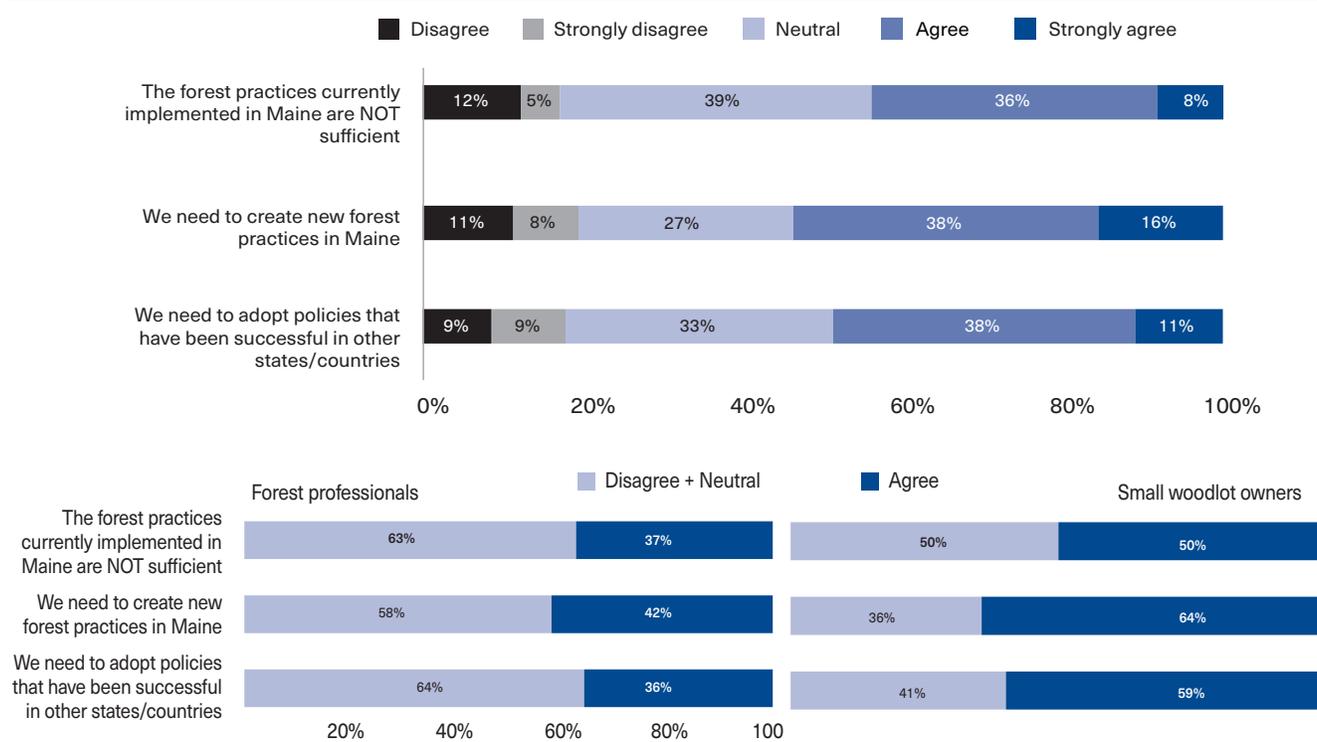
Note: presented as bar chart and table and pie charts for stakeholder groups where the grey slice represents the percentage of respondents who agreed or strongly agreed with the statement.

favor the creation of new forest policies and practices more so than the latter. The increased inclination among small woodlot owners for new policies could be a combination of two factors. One, small woodlot owners may genuinely perceive the need for new policy or at least adjustments to existing policy. A small woodlot owner with over 50 years of experience descri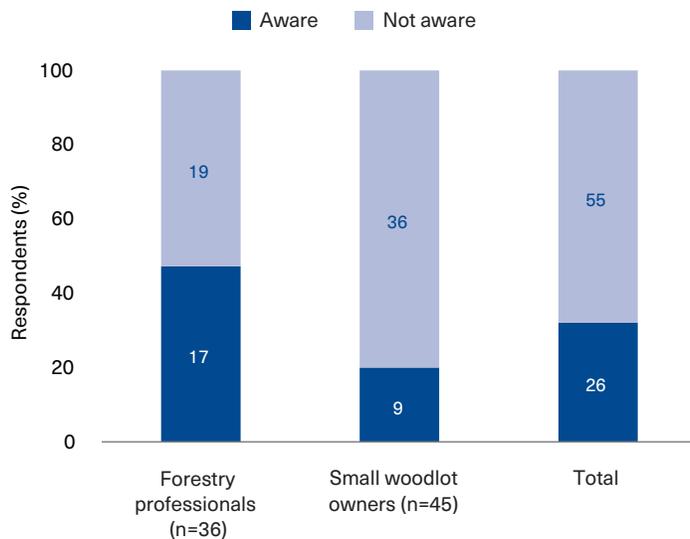bed the need for "sustainable forest benefits that actually provide landowners with financial benefits." When developing new policy, it will be important to consider the multiple uses of land, such as harvesting, biodiversity, recreation, and conservation, along with the varied needs of landowners (e.g., financial incentives or profit, decision-making support for climate change adaptation). Two, some small woodlot owners are unaware of existing policies that can affect their land, such as forest management regulations. Small woodlot owners may also suspect that additional regulations, such as restrictions on clear cutting, do not affect them.

Forest stakeholders may fear increased regulation and therefore hesitate to say that current forest practices are insufficient, which may in part explain the high levels of "neutral" in the responses. Historically, larger landowners have resisted overly restrictive policies that govern practices and limit the supply of raw materials (e.g. the Forest Practices Act). The creation of voluntary instruments as new forest practices, however, could expand managers' options for adapting to the impacts of climate change while avoiding increased mandatory regulations.

When asked about potential forest practices that could deal with the impacts of climate change in Maine, survey respondents indicated a variety of diverse approaches as shown in a word cloud of the most frequently used terms (Figure 2). The largest, and therefore most frequently used, word, forests, often related to participants expressing the need for sound forest management and practices. The words planting and species were often used by participants

FIGURE 2: **Word Cloud from Open-ended Question on Potential Forest Practices to Deal with Impacts of Climate Change**

Note: The size of the word corresponds to how often it was mentioned in the responses.

in the context of planting resilient tree species. Control often related to control of invasive or weed species. Carbon was also frequently discussed by participants as it relates to carbon sequestration and carbon credits.

Based on the analysis of participant responses, we identify some categories for suggested forest practices. First, some of the practices fall under the umbrella of silviculture and sustainable forest management, for example, allowing for longer rotations, harvests and thinning, managing for downed woody debris, and promoting age and species diversity. One landowner with less than five years' experience shared his view on using strategies like commercial thinning to address the effects of climate change:

> *Forest stocking management* [such as] *pre-commercial thinning in natural or planted stands, weed control with herbicides, [and] commercial thinning can help deal with climate change impacts by creating less competition to individual trees.*

Survey participants often noted that a variety of forest management practices are important for addressing the impacts of climate change. Therefore, practices should be tailored to the needs of the landowners and the specific climate change impacts of concern.

Some participants also mentioned monitoring for both invasive species and insects and pathogens, as well as adapting forest operations by enlarging stream crossings and improving road conditions. Several participants indicated planting and encouraging tree species that are more suited to future climates, while others described managing for a variety of ecosystem services and providing the economic incentives for landowners to do so, including managing for carbon. One forest manager with more than 40 years' experience expressed the importance of using resilient forest practices that allow landowners to financially benefit from providing ecosystem services:

> *With margins for forest management ever shrinking, other sources of revenue from a variety of ecosystem services that have historically not been monetized. For example paying landowners for providing clean air, water, and wildlife habitat. These programs need to be efficient and not lead to additional costs for landowners to comply. The key is that land held under favorable economics will be far more likely to have the resources to move resilience practices forward.*

Moving beyond adaptation, participants often mentioned mitigation strategies that support economic sustainability such as carbon tax breaks. Approaches that consider the triple bottom line—or people, planet, and profit—may be applied to policies and practices to ensure widespread support among forest stakeholders managing land for multiple uses. Practices that account for local values and public access, conservation targets, environmental quality, and business profitability appear important.

The perceived need for new policies and practices may also entail loosening, adjusting, and reevaluating some existing policies. Current regulatory policies may be working against managing for resilient and healthy forest systems in Maine by limiting stakeholder flexibility in decision-making. Forest stakeholders, especially forestry professionals, indicated that there are current Maine forestry-related policies that make it difficult to manage for climate change (Figure 3). A forester with 25 years' experience indicated the need for "a broader, less restrictive ability to manage, especially the restrictions on clearcut size and adjacency." New policies that allow for flexibility while promoting sustainable forest management may receive support from a diversity of forest stakeholders.

Stakeholder Awareness of Maine Forest Policies That Limit Ability to Manage for Resiliency

Note: Responses only shown for those who responded to the question.

These policies may allow landowners to choose from a variety of low-cost forest management options that offer relatively quick savings on investment while potentially achieving multiple objectives simultaneously (e.g., Daigneault et al. 2021). Paying attention to the interactions between climate, forest management, and forest policy will be crucial. As an example, respondents noted the need for greater harvesting allowances if climate conditions warrant them, which may involve revisiting current policies to ensure they allow for adaptive management. Specifically, most respondents who were aware of restrictive policies cited the Forest Practices Act, complaining about its lack of flexibility and high compliance costs. The Forest Practices Act was passed by the legislature in 1989 and is continually revised. It intends to promote sustainable forests and regulates clear-cutting and liquidation harvesting. Respondents also mentioned shoreland zoning policies and the Tree Growth program as barriers to managing for multiple uses.

At times, survey responses directly opposed each other, with some stakeholders suggesting stricter guidelines on clear-cuts and harvesting and others calling for greater flexibility in policies for clear-cuts and harvesting. Regardless, policies and practices will need to be tailored to the needs of different landowners and be flexible enough to ensure adaptive management of land for multiple objectives.

Climate Change Adaptation Incentives

Most survey respondents who saw the need for new policies or management practices recommended opt-in, incentive-based measures. Specifically, both forestry professionals and small woodlot owners highly ranked tax breaks and green certification (Figure 4). Several stakeholders indicated an interest in tax breaks that would reward them financially for carbon sequestration. Economic incentives through tax breaks is one area where adaptation efforts can be combined with larger mitigation measures. Tax breaks that not only support carbon sequestration, but also allow flexibility in managing resilient forest systems may receive widespread support from forest stakeholders. While green certification was indicated as important for both stakeholder groups, a greater percentage of forestry professionals indicated certifi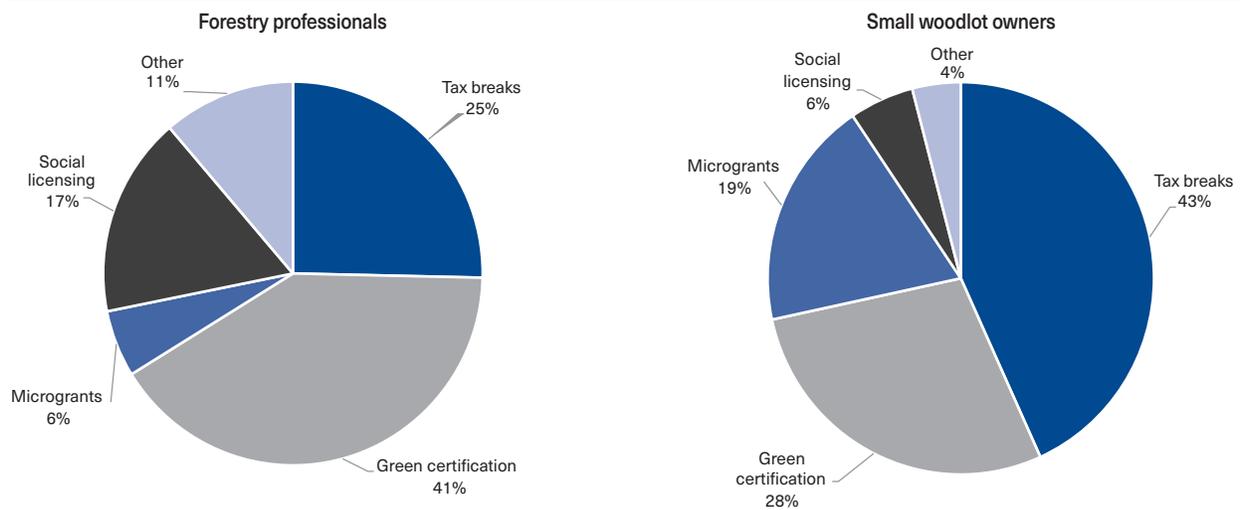cation was a top incentive compared to small woodlot owners, perhaps because the high costs of certification programs creates a financial barrier for some small woodlot owners. Larger landowners and managers may also like the idea of green certification as a form of corporate marketing to consumers.

Industry stakeholders also liked using social licensing as an incentive. Social licensing, related to the concept of corporate responsibility, refers to community support for forestry operations due to positive perceptions of the industry (Lähtinen et al. 2016). Social licensing can be critical for the success (or failure) of forest policies and practices as public opinions can influence decision makers and grant informal acceptance of industry practices. Nearly 20 percent of forestry professionals indicated social licensing as a top incentive. Public relations efforts that engage local community members in conversations about climate change adaptation for industrial forest settings may be one strategy to address social licensing and create incentives for larger landowners to implement adaptation strategies.

Perceived Barriers to Climate Change Adaptation

Even when options for climate change adaptation and systems for landowners to opt in to voluntary sustainable forest management programs exist, stakeholders can still

FIGURE 4: **Incentives for Climate Change Adaptation for Forestry Professionals and Small Woodlot** Owners

Forestry professionals

Tax breaks 25%
Other 11%
Social licensing 17%
Microgrants 6%
Green certification 41%

Small woodlot owners

Tax breaks 43%
Other 4%
Social licensing 6%
Microgrants 19%
Green certification 28%

Note: Based on the percentage of respondents who ranked each incentive as their top incentive. "Other" includes carbon offsetting, financial incentives for ecosystem services, and education.
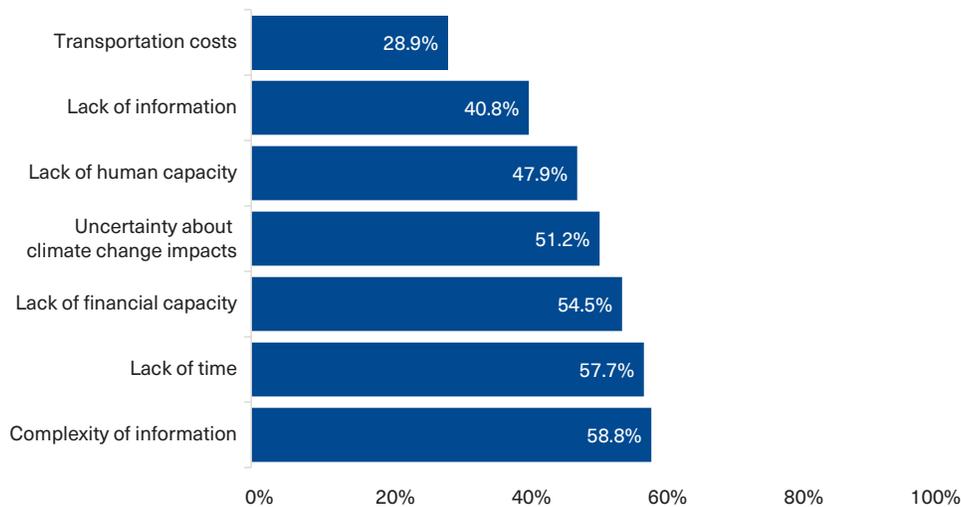
perceive barriers to adopting forest management practices to adapt to climate change. Our survey found the top barriers to climate change adaptation were complexity of information, lack of time, limited financial capacity, and uncertainty about climate change impacts (Figure 5). Both small woodlot owners and forestry professionals cited similar barriers; however, small woodlot owners ranked financial incentives and lack of access to information as slightly larger barriers than did forestry professionals (Soucy et al. 2020). These top barriers highlight the need for incentive-based policies that aid land managers and landowners as they implement adaptation strategies.

A better understanding of forest stakeholders' perceptions of information complexity and uncertainty will help policymakers overcome those barriers to adaptation. For example, there may be a need to create incentives for stakeholders who adopt climate change adaptation strategies that they perceive as having uncertain consequences (e.g., planting tree species suited to future climates). These efforts, which have long-term (50–100 years) benefits, may be too costly for land managers and owners to invest in without financial incentives. While forest stakeholders may be willing to take adaptive measures, they may be unsure which specific action or practice would be most appropriate for their land given the suite of climate change impacts. Uncertainty regarding specific actions and

difficulty in accessing or evaluating information may lead to inaction (Bissonnette et al. 2017).

Forest stakeholders described the specific ways in which climate change information is complex. The first barrier for some is that the information is not widely available or well advertised. As one small woodlot owner with over 50 years' experience wrote, "What information?... There really isn't any that reaches landowners." When they did find information, however, forest stakeholders said that the information was often not practical or relevant at the scale of their operations. Another respondent, a land manager with nearly 50 years' experience wrote, "[information is] too theoretical and not practical on a large, meaningful scale." Therefore, information that focuses on models and predictions may not be relevant for landowners trying to make management decisions for their specific objectives on their particular pieces of land. Information that seeks to help forest stakeholders adapt to climate change must also consider the varied goals of landowners and managers, both environmental and economic. Respondents remarked that much available climate change information does not consider economic goals of landowners. Similar to forest policies and practices, climate change information for forest stakeholders must consider all landowner objectives and goals, including environmental, social, and economic.

FIGURE 5: Stakeholder Perceptions of Barriers to Climate Change Adaptation (n=170)

and mitigation (81 percent), learning from others (74 percent), more training (68 percent), and opportunities to work across organizational boundaries (63 percent). There were no significant differences between small woodlot owners and forestry professionals; therefore, the results represent a unified voice for the need for decision-support tools. Better predictive tree species models and accurate long-term weather forecasts at a local scale are some examples of improved climate science. Showcasing successes in the form of case studies may also be an opportunity to increase adaptation implementation.

As a countermeasure to overly complex information, survey respondents called for practical, straightforward, and concrete recommendations that offer options for adaptation. A government official with 10 years' experience wrote,

> *There is massive information available on climate change. I have yet to see a good source that distills this down to a set of clear, concrete recommendations that forest managers can adopt.*

Although there are adaptation menus, the options being presented may not be clear, practical, or relevant enough to meet the diverse needs of forest stakeholders in Maine. Communications must focus on what landowners value most (e.g., wildlife or forest health concerns) and connect landowners' personal experiences and management needs with specific understandable and achievable adaptation actions (Soucy et al. 2020). Discussions can also consider ways to overcome financial constraints between the short-term costs of adaptation and the long-term pay back. Specific adaptation options with a relatively quick return on investment—both in terms of financial value and ecosystem services that cannot be easily monetized like clean water, air, and aesthetic beauty—can be potential low-hanging fruit for landowner investment.

To help them make decisions about climate change adaptation, forestry professionals in our survey mentioned the following issues: improved climate change impact science (88 percent), case studies of successful adaptation

DISCUSSION

Current Forest Practices and Policies

We now return to the original question posed at the outset of this analysis, Are current forest practices and policies sufficient to deal with the impacts of climate change? If the goals of current policies and practices are to maintain forest productivity, sustain the livelihood and well-being of forest stakeholders and the communities that rely on them, and manage forest health and biodiversity in a changing climate, it is time to reevaluate the extent to which these goals are being achieved with traditional voluntary and regulatory policy instruments. Forest stakeholders in the state have varied opinions on the extent to which current forest policies and practices are sufficient. The multiplicity of opinions largely reflects the diversity of forest stakeholders in Maine who have varying management objectives and goals as well as different land-holding sizes. While some believe we need new policies and practices to address climate change impacts, others are hesitant to increase regulations related to forest management. Additionally, even among those who believe current forest practices are insufficient, some may still be unsure about increasing regulations. Regardless, it is important to note

that most forest stakeholders believe that climate change is real and is having an impact on the forest; therefore, given the willingness of stakeholders, now is the time to act (Soucy et al. 2021).

Addressing key barriers such as information complexity and lack of resources is an important step in ensuring measures are supported. A combination of voluntary instruments, concrete adaptation recommendations, and revisions to current forest policies to respond to the impacts of climate change appears necessary. However, policymakers will need to pay careful attention to the different needs of forest stakeholders.

POLICY DIRECTIONS

Reevaluate Existing Forest Policies and Practices

As a first step, policymakers need to reevaluate current forest policies and practices that may limit landowners' ability to manage for resilient and diverse forest systems. Forest stakeholders, especially larger landowners and managers, expressed a concern for overly restrictive and highly prescriptive policies that hinder their ability to manage under changing climate conditions. Landowners have specific tools they can use to respond to change, and regulations that restrict use of certain tools can potentially limit the extent of landowners' ability to adapt to climatic changes. As an example, restrictions on vegetation management can lead to specific impacts, both positive and negative, on long-term forest composition and resilience (Bataineh et al. 2013). In addition, important unintended consequences, such as a fragmented forest landscape, can occur when regulations restrict the use of certain options or are not applied at the appropriate spatial scale (Legaard et al. 2015).

Discussions with stakeholders should consider specific concerns to ensure current policies have their intended consequences and empower landowners with a variety of management options, while ensuring that these regulations are enforced on appropriate scales. Specifically, increasing the flexibility of approaches that encourage sustainable and science-based forest management, such as outcome-based forestry, is one option (Doty 2019). Outcome-based forestry addresses many of the unintended consequences of the Forest Practices Act by allowing landowners to replace the regulations imposed by the act with a focus on results-based forestry. Outcome-based forestry seeks to ensure forest ecosystem health, biological diversity, timber supply and quality, and social impacts. Currently, four landowners have worked with the Maine Forest Service to implement outcome-based forestry. The environmental, social, and economic benefits, however, suggest there is potential for increasing its use in Maine.

Opt-in, Incentive-based Policies

Given what we learned from our survey, opt-in, incentive-based policies will receive more widespread support compared to mandated regulatory policies. Specifically, because of the uncertainty regarding climate change impacts and viable actions, policymakers need to develop policies that financially reward foresters for their efforts at climate adaptation. These efforts may have long-term benefits and can be costly; therefore, incentives for adaptation strategies—especially for those that are more experimental in nature (e.g., guiding changes in species composition)—can reduce barriers and facilitate adoption. Economic incentives such as microgrants and tax breaks can help individuals cover the costs of sustainable forest practices that they may be unable to afford otherwise.

For example, Maine's Open Space taxation program is an opt-in program for landowners with less than 10,000 acres of land. The program can reduce property values (a tax break) when the land is preserved or managed for public benefit (e.g., recreation, wildlife habitat, conservation). This taxation program could be structured to create incentives for small landowners to implement climate-friendly activities. For those who want to actively manage for timber and tree growth, the Tree Growth program is well suited to meet their management objectives. Additionally, policymakers and forest stakeholders can jointly revisit forestry best management practices (BMPs) for adapting to climate change. Current BMPs are designed to protect water quality through voluntary training and monitoring programs. Policymakers should consider developing climate change BMPs that uphold adaptation strategies based on scientific forestry, but also allow operations to remain profitable.

Integrate Adaptation Efforts into Larger Statewide Mitigation Efforts

Forest-related climate adaptation efforts should be joined with statewide climate mitigation efforts, which focus on larger-scale environmental sustainability issues (e.g., carbon sequestration, energy efficiency). Policies or

practices that address both adaptation and mitigation concerns can be a valuable use of resources. For example, creating programs that allow landowners to sell carbon credits, while also managing for a variety of ecosystem services, can be a powerful tool in responding to climate change. As an example, Maine may look to Vermont's Forest Carbon Cooperative,[2] where landowners are working together to enroll in a voluntary carbon market.

Increase Communication and Outreach Efforts

To ensure that policies address stakeholder concerns, the state needs collaborative outreach approaches to maximize the effectiveness of research and policy. Given the diversity of forest landowners in Maine—industry, investment firms, government, nonprofits, small woodlot owners, conservation groups—the challenges of crafting climate change policies are even more complex. A one-size-fits-all approach is not well suited to the mix of landowner types in the state. Outreach and education programs for small woodlot owners, such as WoodsWISE, can explicitly address climate change adaptation strategies.

As the survey results indicate, some small woodlot owners express concerns that climate change adaptation information is not reaching them. For small woodlot owners, climate change information needs to be made more widely accessible through outreach materials and district foresters who can help them address climate change issues. Increasing the accessibility and availability of information is only half the challenge. Survey respondents also indicated available climate change information was too complex, too technical, and not practical or relevant. For outreach and communication efforts to be successful, they should address the complexity of climate science information by providing concrete and relevant adaptation actions that connect to stakeholder experiences, beliefs, values, and management objectives (Soucy et al. 2020). Framing the adaptation discussion around forest health and wildlife habitat or tree species that may be well suited to future climates can also help avoid the academic language often associated with adaptation actions. Additionally, there should be opportunities for small woodlot owners to learn from each other perhaps by creating case studies of successful climate change adaptation efforts. For larger, industrial landowners, who value social licensing, there is a need to communicate the successes and philosophy of forestry to the general public to highlight climate change adaptation.

We have represented a variety of policy and outreach strategies that will require varying amounts of resources and have different levels of feasibility. However, some institutional systems are already in place to address climate change adaptation (e.g., outcome-based forestry, Open Space tax program, WoodsWISE), and communication and outreach programs exist to build capacity to respond to change (e.g., Manomet, Forest Stewards Guild, Climate Change Response Framework). As a starting place for ensuring policies and practices address the challenges of climate change, policymakers should consider ways in which it can be addressed through these already existing systems.

CONCLUSION

Not only are forests managed for ecological, social, and economic needs, but they also remain an integral part of Maine's rural communities and cultural traditions. Balancing these ecological, social, economic, and cultural values is made increasingly complex by the challenges of climate change. Crafting policy strategies will require creativity and collaboration among stakeholders from diverse backgrounds with varying management objectives. The diversity of forest landowners in Maine is a part of what makes the state's forest industry unique. Successful adaptation, therefore, necessitates that we capture their diversity of experiences, knowledge, and concerns. While Maine can learn from forest policies that have worked in other states, there may not be one solution, but rather a mix of policies and practices that empower landowners to choose from an array of options that suit their needs.

Developing forest policies and practices for the multiple values associated with Maine's forests requires continued discussion and more specific information on options in a changing climate. We should continue to revisit the question of whether current forest policies and practices are adequate to deal with the impacts of climate change and sustain forest ecosystems, the forest industry, and those that rely on them. Additional questions that require careful consideration include

- How can forest landowners adapt to climate change while remaining profitable?
- What specific and concrete adaptation recommendations can landowners apply?
- How can adaptation efforts complement existing demand for carbon markets?

- What measures can ensure policies address the diversity of stakeholder objectives and needs? and
- How can different institutions collaborate to increase the forest industry's ability to respond to change?

Given the complexity of climate change adaptation, these questions are multifaceted and will likely not have one correct answer. They do, however, serve to advance discussions of the critical issue of climate change adaptation in Maine discussions that are necessary to ensure the continuation of the state's forest ecosystem and industry for future generations.

NOTES

1   More information is available at the following websites: https://www.mainewoodlandowners.org/ and https://umaine.edu/cfru.

2   https://vlt.org/forestcarbon

REFERENCES

Bataineh, Mohammad M., Robert G. Wagner, and Aaron R. Weiskittel. 2013. "Long-Term Response of Spruce–Fir Stands to Herbicide and Precommercial Thinning: Observed and Projected Growth, Yield, and Financial Returns in Central Maine, USA." *Canadian Journal of Forest Research* 43(999): 385–395. https://doi.org/10.1139/cjfr-2012-0343.

Bissonnette, Jean François, Jérôme Dupras, Frédérik Doyon, Clément Chion, and Jonathan Tardif. 2017. "Perceptions of Small Private Forest Owner's Vulnerability and Adaptive Capacity to Environmental Disturbances and Climate Change: Views from a Heterogeneous Population in Southern Quebec, Canada." *Small-Scale Forestry* 16(3): 367–393. https://doi.org/10.1007/s11842-016-9361-y.

Daigneault, Adam, Erin Simons-Legaard, Sonja K. Birthisel, Jen Carroll, Ivan J. Fernandez, and Aaron R. Weiskittel. 2021. *Maine Forestry and Agriculture Natural Climate Solutions Mitigation Potential Final Report.* Center for Research on Sustainable Forests. University of Maine, Orono, ME. http://dx.doi.org/10.13140/RG.2.2.35774.00325/2.

Doty, Jon. 2019. *Outcome-Based Forestry: A Case Study of the First Private Landowner's Implementation of an Alternative to Maine's Forest Practices Act.* NEFIS Publication 15229, Center for Research on Sustainable Forests, University of Maine, Orono. https://nefismembers.org/wp-content/uploads/2019/03/jdotyFinalThesis.pdf.

FOR/Maine. 2018. *Forest Opportunity Roadmap/Maine: Vision and Roadmap for Maine's Forest Product Sector.* Augusta, ME: Forest Opportunity Roadmap/Maine.

Fernandez, Ivan, Sean Birkel, Catherine Schmitt, Julia Simonson, Brad Lyon, Andrew Pershing, Esperanza Stancioff, George Jacobson, and Paul Mayewski. 2020. *Maine's Climate Future.* Orono, ME: University of Maine. https://climatechange.umaine.edu/wp-content/uploads/sites/439/2020/02/Maines-Climate-Future-2020-Update-3.pdf.

Hotte, Ngaio, Colin Mahony, and Harry Nelson. 2016. "The Principal-Agent Problem and Climate Change Adaptation on Public Lands." *Global Environmental Change* 36:163–174. https://doi.org/10.1016/j.gloenvcha.2016.01.001.

IPCC. 2021. *Climate Change 2021: The Physical Science Basis.* Contribution of Working Group I to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change, edited by V. Masson-Delmotte, P. Zhai, A. Pirani, S.L. Connors, C. Péan, S. Berger, N. Caudet, et al. Cambridge University Press. In Press.

Irland, Lloyd C. 2005. "U.S. Forest Ownership: Historic and Global Perspective." *Maine Policy Review* 14(1): 16–22. https://digitalcommons.library.umaine.edu/mpr/vol14/iss1/6/.

Irland, Lloyd C. 2020. "From Wilderness to Timberland to Vacationland to Ecosystem: Maine's Forests, 1820–2020." *Maine Policy Review* 29(2): 45–56. https://doi.org/10.53558/VAZE9112.

Janowiak, Maria K., Anthony W. D'Amato, Christopher W. Swanston, Louis Iverson, Frank R. Thompson, William D. Dijak, Stephen Matthews, et al. 2018. *New England and Northern New York Forest Ecosystem Vulnerability Assessment and Synthesis: A Report from the New England Climate Change Response Framework Project.* Gen. Tech. Rep. NRS-173. https://doi.org/10.2737/NRS-GTR-173.

Jin, Suming, and Steven A. Sader. 2006. "Effects of Forest Ownership and Change on Forest Harvest Rates, Types and Trends in Northern Maine." *Forest Ecology and Management* 228 (1–3): 177–186. https://doi.org/10.1016/j.foreco.2006.03.009.

Judd, Richard. 2020. "Maine Conservation in an Age of Global Climate Change." *Maine Policy Review* 29(2): 57–64. https://doi.org/10.53558/WYXI3211.

Lähtinen, Katja, Anne Toppinen, Mirja Mikkilä, Matti Toivio, and Olli Suur-Uski. 2016. "Corporate Responsibility Reporting in Promoting Social License to Operate in Forestry and Sawmilling Industries." *Forestry: An International Journal of Forest Research* 89(5): 525–541. https://doi.org/10.1093/forestry/cpv055.

Legaard, Kasey R., Steven A. Sader, and Erin M. Simons-Legaard. 2015. "Evaluating the Impact of Abrupt Changes in Forest

Policy and Management Practices on Landscape Dynamics: Analysis of a Landsat Image Time Series in the Atlantic Northern Forest." *PloS One* 10(6). https://doi.org/10.1371/journal.pone.0130428.

MacDonald, Brooke S., Lydia R. Horne, Sandra De Urioste-Stone, Jane E. Haskell, and Aaron Weiskittel. 2018. "Collaborative Leadership Is Key for Maine's Forest Products Industry." *Maine Policy Review* 27(1): 90–98. https://digitalcommons.library.umaine.edu/mpr/vol27/iss1/22/.

Reed, Mark S., Anil Graves, Norman Dandy, Helena Posthumus, Klaus Hubacek, Joe Morris, Christina Prell, et al. 2009. "Who's in and Why? A Typology of SeAanalysis Methods for Natural Resource Management." *Journal of Environmental Management* 90(5): 1933–1949. https://doi.org/10.1016/j.jenvman.2009.01.001.

Schipper, E. Lisa F. 2006. "Conceptual History of Adaptation in the UNFCCC Process." *Review of European Community & International Environmental Law* 15(3): 82–92.

Soucy, Alyssa, Sandra De Urioste-Stone, Parinaz Rahimzadeh-Bajgiran, Aaron Weiskittel, and Bridie McGreavy. 2020. "Understanding Characteristics of Forest Professionals and Small Woodlot Owners for Communicating Climate Change Adaptation." *Trees, Forests and People* 2: 100036. https://doi.org/10.1016/j.tfp.2020.100036.

Soucy, Alyssa, Sandra De Urioste-Stone, Parinaz Rahimzadeh-Bajgiran, Aaron Weiskittel, and Bridie McGreavy. 2021. "Forestry Professionals' Perceptions of Climate Change Impacts on the Forest Industry in Maine, USA." *Journal of Sustainable Forestry* 40(7): 695–720. https://doi.org/10.1080/10549811.2020.1803919.

Sousa-Silva, Rita, Quentin Ponette, Kris Verheyen, Ann Van Herzele, and Bart Muys. 2016. "Adaptation of Forest Management to Climate Change as Perceived by Forest Owners and Managers in Belgium." *Forest Ecosystems* 3(22): 1–11. https://doi.org/10.1186/s40663-016-0082-7.

Spittlehouse, David L. 2005. "Integrating Climate Change Adaptation into Forest Management." *Forestry Chronicle* 81(5): 691–695. https://doi.org/10.5558/tfc81691-5.

Vulturius, Gregor, and Åsa Gerger Swartling. 2015. "Overcoming Social Barriers to Learning and Engagement with Climate Change Adaptation: Experiences with Swedish Forestry Stakeholders." *Scandinavian Journal of Forest Research* 30(3): 217–225. https://doi.org/10.1080/02827581.2014.1002218.

Alyssa R. Soucy is a graduate student at the University of Maine pursuing a doctorate in ecology and environmental sciences. Her research is currently focused on understanding conservation decision-making in Maine through collaborative research methods.

Sandra De Urioste-Stone isan associate professor of nature-based tourism in the School of Forest Resources and assistant vice president for research at the University of Maine. She is an applied social scientist who focuses on building collaborative models to enhance the adaptive capacity of human-natural systems.

Ivan J. Fernandez, professor of soil science in the School of Forest Resources and Climate Change Institute, studies the biogeochemistry of forested ecosystem responses to a changing environment. He is a member of the Maine Climate Council and cochairs the Council's Scientific and Technical Subcommittee.

Aaron Weiskittel is the director of the University of Maine Center for Advanced Forestry Systems and the Irving Chair of Forest Ecosystem Management. He has been at the University of Maine since 2008 and works directly with the diverse forest stakeholders in the state.

Parinaz Rahimzadeh-Bajgiran is an assistant professor of remote sensing with the University of Maine School of Forest Resources. Her research focuses on sustainable forest management issues through remote sensing and geospatial analysis of vegetation biophysical and biochemical attributes.

Tom Doak serves as executive director of Maine Woodland Owners Association and is a third-generation woodland owner. Early in his career he worked as a forester and land manager for the Bureau of Public Lands, and he has been a licensed professional forester for 30 years.