

Private Woodland Owner Perceptions of Threat and Efficacy Shape Management Responses for Climate Change Adaptation

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Abstract

Private woodland owners (PWOs) face an increasing number of considerations for climate change adaptation and mitigation activities in their forest management. Evidence suggests there may be a disconnect between PWOs' climate change perceptions and behaviors, which can limit implementation. We conducted seventeen semistructured interviews in Maine to develop a typological framework of PWOs based on their perceptions of climate-induced threats and efficacy. Our results produced three types of PWOs: the steady-as-they-go landowner (low perceived threat), the science-driven landowner (high perceived threat; high efficacy), and the seeking-support landowner (high perceived threat; low efficacy). Although all three types of PWOs regularly implemented resistance and resilience practices, their attitudes toward transition practices (i.e., assisted migration) diverged based on their perceptions of threat and efficacy. This typological framework can be used when targeting communications to PWOs regarding the overlap between climate adaptive management and traditional best management practices.

Study Implications: PWOs in our study recognized climate-related impacts while implementing diverse forest management practices to meet both climate-related and non-climate-related objectives. The divergent attitudes toward transition practices exhibited by our three PWO types highlight the notion that adaptive practices can be both intentional and incidental. Our findings suggest that outreach efforts should understand PWO perceptions of climate change threats and their feelings of efficacy in responding to such threats. When combined with knowledge about the overlap between traditional best management practices and new climate-adaptive strategies, extension and outreach efforts can tailor their messaging to fit the appropriate audience.

Keywords: private woodland owner, climate change perceptions, typology, efficacy, adaptive management

Introduction

Forests provide ecological and socioeconomic benefits, yet climate change is creating novel and extreme conditions that threaten forests as well as traditional management practices (Allen et al. 2010; Forzieri et al. 2022; IPCC 2021). New adaptive management frameworks help to address future uncertainty about forest management amid climate change (Golladay et al. 2016; Nagel et al. 2017). However, despite the increase of adaptive forest management frameworks in response to climate change, there is still concern that small-scale private woodland owners (PWOs) are not adopting beneficial practices. To develop communication aimed at increasing climate adaptation in small-scale private forest ownerships, we must improve our understanding of how PWOs perceive the threats that climate change poses to their properties as well as their perceived efficacy in implementing adaptive management practices (McGann et al. 2022; Soucy et al. 2020).

By combining qualitative interview data, psychosocial theory of threat and efficacy, and typological analysis, this study provides insights for better understanding and communicating with PWOs about adaptive management in response to

climate change. We developed a specific typology that affirms previous work on climate change attitudes and adaptive management behaviors among PWOs (Boag et al. 2018), which may help forestry outreach organizations tailor their communications to diverse landowners. Our findings also lay a foundation for further robust studies of PWO attitudes and behaviors toward forest management for climate change adaptation. We pursued two primary research objectives: (1) explore whether and how a threat-and-efficacy theoretical framework is useful for constructing a PWO typology based on perceptions of climate change and adaptive management; and 2) identify whether and how climate change threat and efficacy perceptions may relate to PWO management practices.

Background

Forest management can address climate change through adaptation and mitigation strategies. Adaptation strategies are driven by the desired future conditions of a forest or stand (Janowiak et al. 2014). Foresters can seek to maintain current conditions amid climatic change ("resistance"), they

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can proactively alter the system in anticipation of future conditions (“transition”), or they can manage to allow for some flexibility in the system while maintaining the major structural components (“resilience”) (Millar, Stephenson, and Stephens 2007). On the other hand, mitigation strategies seek to use the forest’s ability to sequester atmospheric carbon dioxide through photosynthesis to reduce greenhouse gases that drive climate change. Such strategies can strategically promote certain trees or stands based on their ability to capture atmospheric carbon dioxide (Ontl et al. 2020). In this study, we use adaptive management, adaptive practices, and adaptive behaviors to include any type of forest management action that is motivated by the impacts of climate change. Although management strategies that promote climate change adaptation and mitigation have been implemented across a range of forest ownerships (Fischer et al. 2024; Nagel et al. 2017; Peterson St-Laurent et al. 2021), they are still underutilized in small-scale private woodlands (Janowiak, Mahaffey, and Riely 2020; McGann et al. 2022).

Private woodland owners (also known as family forest owners or nonindustrial private landowners) include individuals, families, trusts, estates, and any other unincorporated group that owns private forestland (Family Forest Research Center 2020). PWOs control over 260 million ac (greater than one-third) of woodlands in the United States (Butler et al. 2021). Therefore, PWO management decisions have large cumulative effects on forested landscapes (Sass et al. 2023). Previous reports suggest that some PWOs were not concerned about climate change (Butler and Butler 2016; vonHedemann and Schultz 2021), whereas others were concerned but did not always implement adaptive behaviors (Boag et al. 2018; Sousa-Silva et al. 2016). This was especially true if they had not directly experienced adverse effects of climate change on their woodlands (Hengst-Ehrhart 2019; Lenart 2014). Regardless, PWOs often report feeling that they lack information about how to effectively execute specific adaptation and mitigation strategies (Grotta et al. 2013; Soucy et al. 2020). Collectively, these results suggest that we need a better understanding of the basis by which PWOs choose to manage their land in response to climate change (Huff et al. 2017; Silver et al. 2015).

To improve our understanding of how perceptions of threat and efficacy influence PWO adaptations to climate change, we used conceptual frameworks stemming from protection motivation theory (PMT; Rogers 1975), which was created to analyze how individuals protect themselves amid fearful situations (Rogers 1975). The extended parallel process model of fear appeals (EPPM; Witte 1992) outlines the process of how fear appeals translate into actions. EPPM asserts that in a fearful situation a perceived threat triggers a control response, in which an individual attempts to control the situation. An individual’s specific control response depends on efficacy: perceived efficacy triggers a danger-control process (protection motivation) in which the individual seeks to control the objective danger, whereas perceived lack of efficacy triggers a fear control process (defensive motivation), in which the individual seeks to simply control their fear. In the context of messaging intended to change individual behaviors, danger-control responses are theorized to promote message acceptance whereas fear control responses are theorized to promote message rejection (Witte 1992). Although EPPM has predominantly been used to evaluate public health messaging intended to promote public adoption of certain behaviors

(Birmingham et al. 2015; Maloney, Lapinski, and Witte 2011; Reno and Dempsey 2023), the core tenets of threat and efficacy have shown promise for understanding public perceptions of climate change (Grothmann and Patt 2005; Sarrina Li and Huang 2020; Wilson et al. 2020; Xue et al. 2016).

The model of private proactive adaptation to climate change (MPPACC; Grothmann and Patt 2005) builds on PMT and EPPM to explicitly explain psychosocial factors determining individual adaptive actions to address climate change. Inputs into MPPACC (risk perception and perceived adaptive capacity) are closely related to perceived threat and perceived efficacy from EPPM. However, MPPACC expands on the EPPM’s fear-control processes by explaining resultant behaviors in the context of climate adaptation, rather than simply describing message acceptance or rejection. MPPACC describes fear-control processes as avoidant maladaptive behaviors, such as fatalism, denial, and wishful thinking. On the other hand, danger-control processes lead to the implementation of adaptive behaviors (Grothmann and Patt 2005).

To better understand and communicate with PWOs regarding climate change and adaptive management, it could be helpful to classify their attitudes and behaviors using a typological approach. Typologies are commonly used in psychology and sociology to differentiate groups within a population based on defining characteristics (Mandara 2003), which can inform policy decisions and outreach efforts (Jansujwicz et al. 2013; Juerges, Leahy, and Newig 2020). Typologies have been used to understand PWO values and priorities regarding ownership and management of their land (Ross-Davis and Broussard 2007), with one of the most commonly recognized typological frameworks being the Tools for Engaging Landowners Effectively (TELE) program (Butler et al. 2007). Understanding the distinctions between groups of PWOs is essential for effectively tailoring forest management services and recommendations (Butler et al. 2007; Ficko and Boncina 2013; Finley and Kittredge 2006; Starr et al. 2015). In existing typologies of climate change perceptions among PWOs, landowners differed based on their level of concern about climate change as well as their preferred mitigation strategies (Karppinen, Hänninen, and Valsta 2018; Kelly, Gold, and Di Tommaso 2017; Khanal et al. 2017). However, there have been no typological studies of PWOs explicitly based on threat and efficacy as they relate to perceptions of climate change and adaptive management. Given the utility of typologies for categorizing variation within a population, we seek to understand whether this method could be used to better understand the attitudes and behaviors that PWOs exhibit specifically toward climate change and adaptive management.

Methods

To effectively capture the level of nuance inherent in assessing different psychosocial drivers of climate adaptation, we used an in-depth qualitative approach using semistructured interviews (Bissonnette et al. 2017; Bliss and Martin 1989). Although our analyses were supported by theoretical frameworks from EPPM and MPPACC, our approach also used emergent themes from our qualitative data to iteratively refine conceptual frameworks throughout the research process (Strauss and Corbin 1998).

Our study was located in Maine, USA (figure 1), which is the most heavily wooded state in the country, with 89% of the total land area covered by forest (Butler 2018). Maine

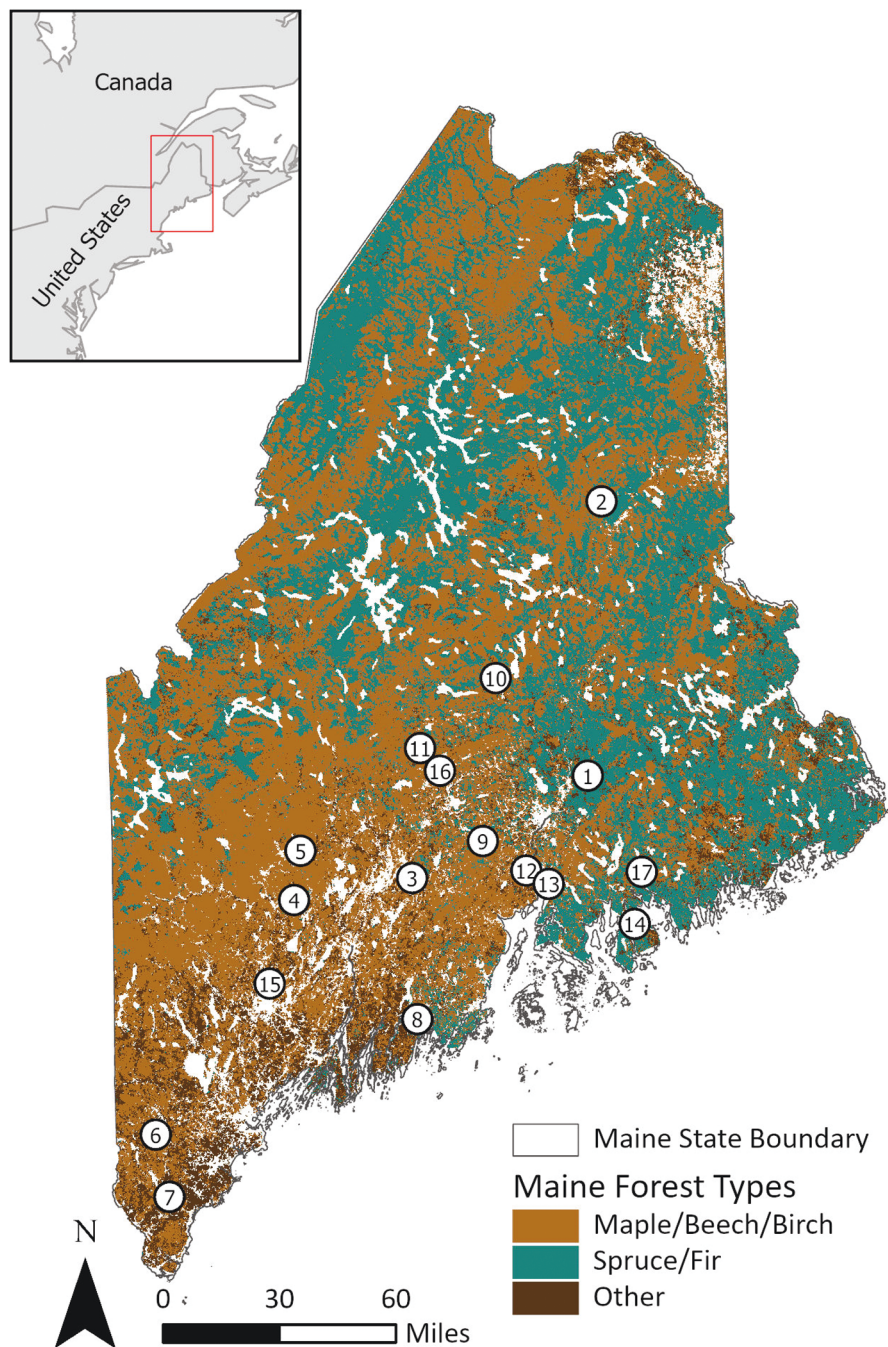


Figure 1 Map of study area showing Maine, USA, and its location in North America (inset), as well as approximate locations of private woodland owner (PWO) interviews. Numbered symbols correspond to the identification code (PWO#) used for participant quotes. Map is symbolized to show the modeled distribution of Maine's major forest types (USDA Forest Service Forest Inventory and Analysis & Geospatial Technology and Applications Center 2008).

has nearly 80,000 PWOs who own 34% of the state's forested land (Butler 2018). The state is located along the Gulf of Maine, which is in the top 5% of fastest warming bodies of water in the world (Karmalkar and Horton 2021). Climate change is most noticeably affecting Maine through milder winters, longer growing seasons, and more extreme weather events denoted by large precipitation events interspersed with periods of intense drought (Fernandez et al. 2020).

Participants were recruited by self-selection sampling (Llewellyn, Sullivan, and Minichiello 2004), with advertisements placed in the Maine Woodland Owners' newsletter

and Maine Forest Service Woods Wise Wire email listserv in July 2022. Maine Woodland Owners is a statewide nongovernmental organization with approximately 3,000 members, whereas the Maine Forest Service listserv included 6,210 recipients at the time of recruitment. In addition, we used network sampling (Llewellyn, Sullivan, and Minichiello 2004) with Natural Resources Conservation Service Technical Service providers to identify potential study participants. Our study sample mostly consisted of highly engaged forest landowners with an interest in discussing their attitudes toward climate change and forest management. Although

our participants are not necessarily representative of the full spectrum of PWOs in Maine, their high level of interest and engagement allowed for in-depth, robust discussions about psychosocial drivers of climate adaptation in small-scale private woodlands.

We conducted seventeen semistructured interviews from August to October 2022. Interviews occurred in person at participants' properties. Most interviews were conducted while walking through participants' woodlands, which allowed for depictions of forest management practices and climate-related impacts to the land. Participant recruitment was continual until theoretical saturation was reached (i.e., no new codes or themes were identified; Glaser and Strauss 1967; Lewis 2015). All interviews were recorded and subsequently transcribed; the written transcripts were then used as data sources for qualitative coding.

Our study participants consisted of seventeen woodland owners with property sizes ranging from 20 to 970 ac. Nearly two-thirds of participants were over 65 years old, whereas the remainder were 35–64 years old. Two of our participants identified as women and fifteen identified as men. For race and ethnicity, fourteen participants were White, one was American Indian or Alaska Native, and two participants reported an ethnicity not provided on the survey (i.e., "other"). Nearly half of participants had a higher degree in natural resources or professional experience related to forest management. Additionally, almost half of participants had a consulting forester, whereas one-fourth had no consulting forester and one-fourth wrote their own management plans.

Our interviews focused on three key topics: (1) current and past management, to establish baselines regarding individual landowner values and management preferences; (2) climate change perceptions, where we explored concerns (or lack thereof) about climate change threats to their woodlands; and (3) future plans, to understand whether climate change altered the ways they intended to manage their forests moving forward (see [Supplementary data](#) for full interview guide). All questions were open-ended, which allowed for exploration of unique topics that were of interest to each respondent. The interview guide was pretested on two PWOs.

Interview data were analyzed using open and thematic coding in Taguette (Version 1.3.0, Remi Rampin and Taguette contributors 2018), in addition to memo writing (Saldaña 2009). For creation of the landowner typology, we used our theoretical frameworks to inform codes via a two-step question: (1) is the participant concerned about climate change (i.e., is there a perceived threat) and (2) do they feel empowered to adapt

(i.e., is there a perceived sense of efficacy)? This led to the creation of over forty qualitative codes which were grouped into two conceptual themes of climate change threats and efficacy. Following the ideal type analysis process (Stapley, O'Keeffe, and Midgley 2022), we used our thematic codes to summarize the narrative of each interview (i.e., "case reconstruction"). We then compared and contrasted these case reconstructions to identify groups of cases (i.e., "ideal types") based on emergent patterns among the narratives and qualitative codes (Stapley, O'Keeffe, and Midgley 2022). From these analyses we identified three key landowner types present in our study.

To identify relationships between climate change perceptions and forest management practices, we analyzed the management preferences of each landowner type across a spectrum of adaptation options. Here, we used the resistance, resilience, transition framework (Millar, Stephenson, and Stephens 2007) as a guide and also coded interview responses to differentiate between intentional and incidental adaptations (Boag et al. 2018). We defined intentional adaptations as those in which the participant's actions were motivated by perceived climate change threats, whereas incidental adaptations were not motivated by perceived threats yet may still increase the forest's adaptability to climate change.

Results

PWO Typology

To address our first research objective, we developed a typological framework based on our participants' perceptions of threats from climate change as well as their feelings of efficacy in addressing such threats ([figure 2](#)). Although all study participants acknowledged the presence of climate change in Maine and beyond (e.g., warming temperatures, extreme precipitation), they expressed varying levels of concern about its effects on their woodlands in addition to differing levels of empowerment regarding adaptive responses. Based on our threat-and-efficacy framework, we identified three types of PWOs: the steady-as-they-go landowner ($n = 5$), the science-driven landowner ($n = 7$), and the seeking-support landowner ($n = 5$; [figure 2](#); [Table 1](#)).

Steady-As-They-Go Landowner

The steady-as-they-go landowner recognized that the climate is changing but is not concerned. This lack of concern may stem from perceived benefits of climate change or feeling that climate change is a natural or inevitable process in line with historical disturbance regimes.

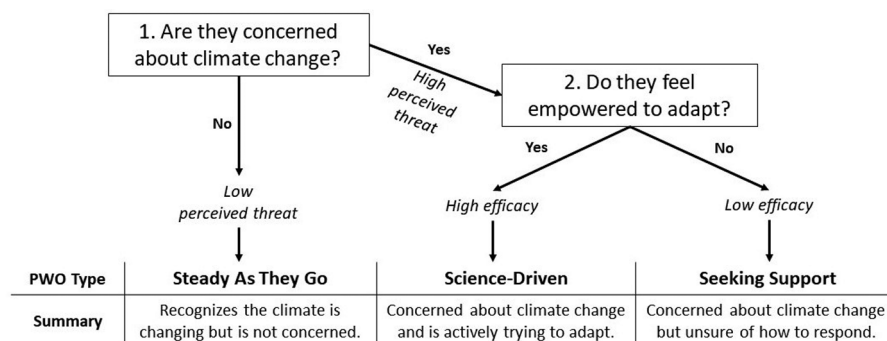


Figure 2 Conceptual model used for developing our private woodland owner (PWO) typology based on semi-structured interviews regarding participants' perceptions of climate change threats as well as their senses of efficacy in addressing such threats with adaptive management.

Table 1. Characteristics of the three PWO types identified using our conceptual framework based on perceptions of climate change threats and efficacy in addressing such threats.

PWO type	Steady-as-they-go	Science-driven	Seeking-support
Exemplary quote	"We're kind of in that sweet spot in terms of climate change... We're on the northern end of the northern hardwood range. Growing hardwood is just fine by me."	"It has to change my management...I lose sleep now, during these droughts. I don't want these trees to die. I didn't raise the trees to die."	"So yes, I'm very, very concerned, but I'm just not sure what I should—what those concerns should be directed at."
Management implications	Focus on traditional best management practices. May be interested to hear about "new" forestry practices, but these recommendations do not need to be framed in the context of climate adaptation.	Receptive to "new" adaptive management strategies that seem to go beyond traditional practices. Ground all recommendations in a scientific understanding of forest ecosystem dynamics and species silvics.	Identify overlap between traditional practices and new adaptive techniques. May be best supported by actions that boost their sense of efficacy, such as building stronger relationships with consulting forester.
Approach to "transition" practices	Hopeful about the economic opportunity to grow high-value central hardwoods outside of their current range in Maine (<i>incidental adaptation</i>).	View assisted migration as an adaptive tool that can be used to increase the climate resilience of threatened stands (<i>intentional adaptation</i>).	Infrequently implement transition practices due to lacking a sense of efficacy.

"So, if I've seen any effect on this forest from climate change, I think it's been perhaps benign at this point. It's things like, you know, the species of birds are changing a little bit" (PWO-16)

"You know, the forest never stays the same. People who talk about the balance of nature have not the faintest idea of what they're talking about. Forests are places of change and disruption." (PWO-8)

"I don't have much faith in humans stopping climate change. I think it's gonna happen—it is happening. I think it's gonna continue to happen, to some degree. So we're just faced with it. It's a reality." (PWO-9)

Moreover, with this type of landowner, the topic of anthropogenic climate change was potentially a cause for contention or skepticism.

"It definitely is warming. We can all see that. But I don't know. The first thing you hear is people caused it. I don't think I believe that. We're not helping, that's for sure." (PWO-2)

The steady-as-they-go landowner was not likely to have experienced major climate-related impacts to their property, and they viewed Maine as having a low vulnerability to climate change.

"I'll admit I haven't followed all that closely. But it seems as though the general idea until this past year was Maine was going to be warmer and wetter. I mean, we're kind of in that sweet spot in terms of climate change... We're on the northern end of the northern hardwood range. Growing hardwood is just fine by me." (PWO-9)

Rather, this type of landowner was primarily concerned with threats to active forest management (logging bans and restrictions), as well as increasing numbers of forest pests and diseases.

"I think we got more problems coming from people than we do global warming. I think there's some resilience there, but we got all these diseases, longhorn beetle, emerald ash borer, of course. People forget Dutch elm, the beech scale,

all those were brought in by people a long time ago." (PWO-2)

Their management was often founded on traditional best management practices (BMPs); when confronted with "new" forestry practices to address climate change, they felt like they had been doing the correct management all along. This contributed to the steady-as-they-go landowner justifying their current management regime amid their perception that climate change posed a minor threat.

"Actually, this carbon sequestration is really what we've done all the time. We've tried to grow the high value species to big size—things that would be used in furniture or construction. The carbon will be stored for years. That's been our goal, without saying it in those words." (PWO-2)

Science-Driven Landowner

The science-driven landowner perceived climate change as a threat to the health of their forest and felt empowered to adapt. The science-driven landowner felt a high sense of efficacy by embracing the inherent uncertainty of climate change and leaning on contemporary research to guide their management. This type of landowner was willing to try "new" adaptive practices to address climate change if they were not already doing them. PWOs of this type described their views of climate adaptation by saying,

"It's just—you got to go with the flow, kind of. You know, assisted migration is one of the biggest things... So I thought that [chestnut oak] might be a good tree that would be adaptable to changing conditions." (PWO-7)

"I'm really interested to know—in terms of management practices—what impacts the climate is going to have on the ability of this property to be healthy... So what else is coming? What else in terms of management do I need to be thinking about to keep the property healthy?" (PWO-14)

For some science-driven landowners, their motivation to adapt was driven by direct experiences with climate-related impacts to their properties. Many landowners believed that

climate change was driving invasions of pests and diseases, in addition to increasing drought stress.

"[We are] extremely concerned. You know, I think we already see significant change, really. The insect populations have changed dramatically in the 20 years we've been here...The drought that we've experienced in the last three years has been at least out of the ordinary for Maine." (PWO-4)

"It will change—it has to change my management. And unfortunately, I'm very resistant to do that. But just at some point—I lose sleep now, during these droughts. I don't want these trees to die. I didn't raise the trees to die." (PWO-6)

This type of PWO had a high sense of efficacy in responding to perceived threats from climate change, which was often bolstered by their training (i.e., bachelor's degree or employment) in forestry or natural resources. Similarly, they tended to engage with primary scientific literature and emerging forestry research, which helped them to view adaptation as an opportunity to experiment in their woodlands.

"You know, I have my colleague contacts in the scientific community, and I still read a bunch of stuff. You know, unnecessarily reading journals..." (PWO-14)

"I read a lot of research...Yeah, the stuff that's written for the public is not specific enough for me." (PWO-7)

Moreover, this type of landowner often boosted their sense efficacy by viewing their management relative to other landowners who they perceived to lack proper forestry knowledge and training.

"The NRCS people love me because I'd already been doing some work. I already knew what I wanted to do with it, you know. They didn't have to come in and like, explain everything to me." (PWO-7)

"I think other landowners are pretty much in denial about climate change. I don't think they understand the severity of it. And they don't get out on their land enough to notice it." (PWO-6)

Although landowners of this type had a range of relationships with their foresters, they often did not rely on a forester for basic information. Some actively exchanged ideas about proper forestry practices, whereas others felt that they had the proper knowledge to effectively manage their property without needing a close relationship with a forester.

Seeking-Support Landowner

The seeking-support landowner was concerned about climate change but was unsure of how to respond. They felt a low sense of efficacy due to a perceived lack of forestry knowledge or simply because the idea of addressing climate change through their management was too daunting.

"So yes, I'm very, very concerned [about climate change]. But I'm just not sure what I should—what those concerns should be directed at." (PWO-5)

"You know, if I probably knew all the ways that [my property] could be affected, I'd probably say yes to all of them. I'm concerned about it." (PWO-5)

Another factor contributing to low efficacy for this type of landowner was feeling overwhelmed by invasive species on their property.

"It's on my list to deal with so many things...At least keep stuff from getting worse. You know, the invasives particularly like the Norway maple [Acer platanoides] and the buckthorn [Frangula alnus]—I've just been trying to keep up with those. And I'd like to do better. But it's hard and takes time to do that. I'll go and spend 30 minutes attacking one area and, well, it looks worse than it did last year." (PWO-12)

Seeking-support landowners were keenly aware of humanity's poor track record regarding environmental issues and often expressed pessimism about society's ability to adapt to climate change on a large scale.

"I have a grim notion of the future, you know, seriously. Was it this week that the report came out that the Arctic ice shelf is melting seven times faster than they thought it was? And every other week, there's something just as nasty." (PWO-3)

"It's just more screwed up by people, for lack of a better term. Like, you know, with all that agricultural kind of history....there's some areas where I think the soil was pretty degraded." (PWO-12)

Despite having such a high reliance on outside information sources for knowledge about forest management, the seeking-support landowner typically lacked a close relationship with a forester. This could be due to a lack of interest on the landowner's part or due to difficulties finding foresters that adequately met their needs. In fact, of the three PWO types in this study, the seeking-support landowner was least likely to have plans for active forest management on their property. This is because they were primarily concerned with protecting their property from development and strongly believed in the power of nature to heal itself.

"I try to take a 'less is more' approach when possible. Yeah, probably because I don't have any like, really specific forestry goals. Mostly, I want it to remain forested and I want it to provide wildlife habitat...So it's like, either humans are going to thin the stock or it's going to thin itself. I'm okay with it thinning itself" (PWO-12)

PWO Management Practices

For our second research objective, we found that PWOs in our study implemented a diverse range of forest management practices to meet both climate-related and non-climate-related goals. To understand how participants' actions fit into a commonly used climate adaptation framework, we categorized their practices along the resistance, resilience, transition (RRT) spectrum and found that their management spanned the entire range of RRT practices. We also found that landowners expressed a range of attitudes toward mitigation practices, with some PWOs being very interested in carbon management programs and some expressing immense skepticism.

We characterize resistance practices as those that are fixated on maintaining the current species composition or stocking level (i.e., invasive plant removal).

“And the other thing is this invasive, you know, the thistle that’s showing up. So, you know, in terms of management, I think I and other landowners need to be more attuned to that and be more vigilant in monitoring, because the best way to deal with it is before it takes hold, right?” (PWO-14)

Resilience practices were characterized as those that intended to increase diversity of species and structure as well as those that maintained flexibility to match changing environmental conditions (e.g., enrichment tree planting).

“I’m not after the money per se. I want the diversity of stuff...I want softwood and hardwood [in my woodlot]. Because depending upon what the future brings, the mixture of those trees is the most likely to survive what’s coming.” (PWO-10)

“I’m trying to keep the forest fairly diversified species-wise, and also age-wise. So if the climate changes impact a particular species of trees, it won’t wipe out my whole 50 years of work.” (PWO-15)

Transition practices were characterized as those that facilitated a shift in species composition or structure based on expected future conditions (e.g., assisted migration).

“The growing season is pushing a month and a half longer than it was when we came in. I planted black walnuts.” (PWO-3)

“Yeah, I planted seedlings [from species] that are here now as well as some from southern New England and mid-Atlantic states.” (PWO-14)

Additionally, several landowners brought up the topic of mitigation practices, such as forest carbon management, which reflected a wide range of perspectives on the topic. Some landowners saw carbon programs as creating new avenues for forest-based income as well as a way to incentivize responsible forest management practices.

“So yes, I’m very much into the carbon, and I want to work that system because I can use that carbon to help pay my property taxes...If I can get some of that money and use it to buy more woodland and take more carbon out of the atmosphere. I can look myself in the mirror and feel that I’m doing the right thing.” (PWO-10)

On the other hand, several landowners expressed skepticism about carbon programs having a real, additional benefit to help mitigate carbon emissions.

“...maybe these carbon programs just allow industry to go on polluting the way they’re polluting, and say, ‘Hey, we’re offsetting our carbon.’” (PWO-7)

“It strikes me that there are some very serious questions about the science here. And the way that the [carbon] programs are structured, sometimes they’re kind of making some assumptions and winking at folks saying, ‘Well,

just don’t worry about it, take the money and run.’ And I would be opposed to that.” (PWO-4)

Interestingly, PWO type generally was not indicative of attitudes toward mitigation practices or of management preferences along the RRT spectrum, as all types of landowners in our study exhibited all types of practices along this spectrum. However, we did find notable differences in PWO approaches to transition practices that diverged based on perceptions of threat and efficacy. For example, steady-as-they-go landowners were hopeful about the economic opportunity to grow high-value central hardwoods (e.g., various oak and hickory species) outside of their current range in Maine, whereas science-driven landowners viewed assisted migration as an adaptive tool that can be used to increase the climate resilience of threatened stands. Although seeking-support landowners often exhibited similar levels of concern as science-driven landowners about climate change threats, they rarely implemented transition practices, perhaps due to lacking a sense of efficacy and generally low levels of forest management activity.

We found that participants exhibited both incidental adaptations, which can unintentionally increase adaptive capacity to climate change, as well as intentional adaptations that were driven directly by observed or expected climate-related stressors. Although steady-as-they-go landowners were typically not concerned about climate change impacts to their woodlands, they often capitalized on changing conditions by planting high value southerly species outside their northern range margins. Science-driven landowners were the most likely to implement intentional adaptations, including assisted migration and stand density reductions in response to climate stressors such as drought. Seeking-support landowners rarely implemented intentional adaptive practices, as this absence of intentional adaptation was a major driver of their lacking a sense of efficacy. However, when guided by a close relationship with their forester, this type of landowner implemented incidental adaptations, such as timber stand improvement and creation of wildlife habitat.

Discussion

We found that PWOs exhibited a range of attitudes and behaviors related to climate change and adaptive management, which is consistent with existing literature. Several studies have found that there is a disconnect between climate change perceptions and behaviors in the global PWO population (Boag et al. 2018; Grotta et al. 2013; Hengst-Ehrhart 2019; Sousa-Silva et al. 2016). Our typological framework based on perceptions of threat and efficacy offers an important preliminary step toward an improved understanding of this disconnect. Our results highlight how seemingly nuanced differences in attitudes and behaviors toward climate change among different types of PWOs can result in divergent approaches to adaptive management.

Previous typologies focusing on climate change perceptions among PWOs have focused on management strategies that promote carbon storage for climate change mitigation (Karppinen, Hänninen, and Valsta 2018; Kelly, Gold, and Di Tommaso 2017; Khanal et al. 2017). Although most of our participants were aware of carbon markets as potential income sources, none of them were currently enrolled in a carbon credit program and many were skeptical about the

current economic and ecological integrity of these programs. The few participants that were seriously considering enrolling were motivated by perceptions of contributing to a greater cause (i.e., mitigating carbon dioxide emissions) and the potential for passive income (Charnley, Diaz, and Gosnell 2010).

In addition to carbon management, we focused on adaptive practices to better understand factors affecting landowner perceptions of threat and efficacy. Study participants that had experienced the impacts to their properties from climate change (e.g., drought stress, extreme storm damage) were most concerned about threats posed by climate change (similar to Blennow et al. 2012). In the absence of clear climate-related impacts, several participants still perceived their properties to be vulnerable to threats such as pests, diseases, and drought stress. These feelings of vulnerability were likely major drivers of perceived threats (Füssel 2007). For landowners that perceived climate change as a threat, feelings of efficacy tended to motivate protective action (Rogers 1975). We found that participants expressing a sense of efficacy were often empowered by their forestry knowledge or training as well as access to supportive information from a forester or outreach organization. For landowners with a strong sense of stewardship, these sources of information likely bolstered their perceived adaptive capacity (Adger et al. 2009; Grothmann and Patt 2005). Additionally, logistical factors likely affected participants' actual adaptive capacity (Grothmann and Patt 2005). For example, issues such as operational costs, finding reputable contractors, and land tenure issues often influenced participants' abilities to carry out desired management activities.

Our study participants implemented practices all along the RRT spectrum, although intentions varied depending on landowner type. Although it has been shown that PWOs are amenable to implementing resistance and resilience practices (McGann et al. 2022), nearly half of participants in our study were already practicing—or seriously considering—transition practices such as assisted migration. Notably, participant approaches to transition practices highlighted the importance of recognizing both incidental and intentional adaptive actions. For example, several steady-as-they-go landowners were practicing assisted migration without identifying it as such (incidental adaptation), whereas most science-driven landowners directly named assisted migration as a tool in their adaptive repertoire (intentional adaptation).

Other studies have noted that to increase widespread adaptation in small-scale private woodlands, it's not about providing *more* information, but *better* or *well-timed* information (Chang et al. 2023; Hengst-Ehrhart 2019; Huff et al. 2017; Sousa-Silva et al. 2016). Although most PWO management preferences fit into current climate adaptation frameworks (such as the RRT spectrum), to effectively tailor outreach and education efforts to landowners, we recommend that foresters understand the motivations that drive the implementation of these practices. In fact, it is entirely possible to implement climate-adaptive management practices (e.g., assisted migration) in the absence of climate change concerns, as other factors (e.g., markets) may play a significant role in motivating such management action. Previous studies have noted that there is often much overlap between climate adaptation strategies and ecological forestry practices (D'Amato and Palik 2021). Therefore, technical support messaging for PWOs can be improved by synthesizing concepts of ecological forestry

and climate-adaptive forestry into integrated prescriptions that simultaneously meet diverse goals.

In terms of management support and outreach, our study suggests that the steady-as-they-go landowner will likely benefit the most from messaging focusing on traditional best management practices. They may be interested to hear about adaptive forestry practices, but these recommendations do not need to be framed in the context of climate adaptation. Science-driven landowners are most likely to be receptive to intentional adaptive management practices that address climate change. When discussing management techniques with science-driven landowners, it is advised to ground all recommendations in a scientific understanding of forest ecosystem dynamics and species silvics. When communicating with the seeking-support landowner for outreach and educational purposes, it is advisable to focus on traditional BMPs and the basic benefits of adaptive management. This group is likely to be receptive to management practices that address climate change, although it is important to identify overlap between traditional practices and new adaptive techniques. This type of landowner may be best supported by simply taking actions to boost their sense of efficacy, such as building stronger relationships with trustworthy consulting foresters.

Study Limitations and Future Research

Although our sample population likely represents a subset of all Maine PWOs, we believe our conceptual framework has highlighted three key types of highly engaged landowners and their perceptions of climate change and adaptive management. Given the limited scope of our purposive sampling approach, we recommend that future research investigating psychosocial drivers of climate adaptation should include quantitative studies on representative sample populations of PWOs to determine how well our framework applies to these populations. Future studies could also build on our work by further investigating PWO demographic, such as assessing the proportion of PWOs that are highly engaged (like our participants) and by including additional participant perspectives, such as women and gender minorities and indigenous worldviews. Although we found that PWO perceptions of threat and efficacy were useful for forming our typology, more explicit tests of specific MPPACC input parameters may provide greater insight for understanding PWO management responses to climate change. Specifically, future research should combine individual drivers of “risk perception” (e.g., probability, severity, cognitive biases), “perceived adaptive capacity” (e.g., adaptation efficacy vs. self-efficacy), and “objective adaptive capacity” (e.g., logistics affecting actual adaptive capacity) as outlined in the MPPACC to better understand different types of landowners with respect to climate-adaptive forest management (Grothmann and Patt 2005).

Conclusions

Increasing our understanding of the psychosocial drivers of climate adaptation can help to inform better tools for engaging and communicating with PWOs about climate change and adaptive management. Our findings suggest that outreach and education efforts should meet landowners at their current level of climate concern by better understanding their perceptions of climate change threats and efficacy in responding

to such threats. When combined with knowledge about the overlap between traditional BMPs and new climate-adaptive strategies, our conceptual framework can shed light on ways to improve communication with PWOs about climate change as well as appropriate contexts for implementing adaptive management.

Supplementary Material

Supplementary material is available at *Journal of Forestry* online.

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Conflict of Interest

None declared.

Data Availability

Data available on request.

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