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Understanding Climate Adaptation on Public Lands in the Upper Midwest: Implications for Monitoring and Tracking Progress

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Abstract There are limited examples of efforts to systematically monitor and track climate change adaptation progress in the context of natural resource management, despite substantial investments in adaptation initiatives. To better understand the status of adaptation within state natural resource agencies, we utilized and problematized a rational decision-making framework to characterize adaptation at the level of public land managers in the Upper Midwest. We conducted in-depth interviews with 29 biologists and foresters to provide an understanding of managers' experiences with, and perceptions of, climate change impacts, efforts towards planning for climate change, and a full range of actions implemented to address climate change. While the majority of managers identified climate change impacts affecting their region, they expressed significant uncertainty in interpreting those signals. Just under half of managers indicated planning efforts are underway, although most planning is remote from local management. Actions already implemented include both forward-looking measures and those aimed at coping with current impacts. In addition, cross-scale dynamics emerged as an important theme related to the overall adaptation process. The results hold implications for tracking future progress on climate change adaptation. Common definitions or measures of adaptation (e.g., presence of planning documents) may need to be reassessed for applicability at the level of public land managers.

Keywords Adaptation tracking · Climate change adaptation · Cross-scale dynamics · Decision making · Public lands

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Introduction

In recent years, the field of climate change adaptation has seen advancements in the development of adaptation principles and strategies, and while there have been substantial investments in adaptation initiatives, there are limited examples of efforts to systematically monitor and track adaptation progress (Ford et al. 2011). In addition to challenges in defining the form adaptation can take, few metrics or indicators for tracking and evaluating adaptation have been developed (Ford et al. 2013). As a result, current efforts to track adaptation are broad, focusing on adaptation at global or national scales or spanning large economic sectors (Berrang-Ford et al. 2011; Bierbaum et al. 2013). Tracking adaptation progress remains a complex, albeit important, task for agencies, non-governmental organizations, and donors looking to understand current adaptation to climate change and to potentially support future adaptation efforts.

Defining Climate Change Adaptation

Adaptation is formally defined by the Intergovernmental Panel on Climate Change (2007) as "the adjustments in natural or human systems in response to actual or expected

climatic stimuli or their effects, which moderates harm or exploits beneficial opportunities" (p. 6). Effective adaptation is often described as an intentional, planned process that requires an understanding of climate change impacts and vulnerabilities and the adoption of strategies designed around that understanding (Stein et al. 2013). Under this characterization, adaptation consists of actions undertaken in the context of changing climatic conditions or through the "lens" of climate change.

In natural resource management, this marks a departure from traditional approaches to managing ecological systems, which assume an underlying natural equilibrium state (Tarlock 1993; West et al. 2009). Under changing climatic conditions, conservation will require new, forward-looking goals and strategies to protect critical ecological services (Mawdsley et al. 2009; Stein et al. 2013). Public lands, in particular, provide an array of economic, social, and ecological benefits including timber production, recreation opportunities, and biodiversity. Thus, agencies, scientists, and policy makers have a vested interest in understanding how to track and evaluate progress towards adaptation goals.

Tracking Adaptation Progress

Directly measuring adaptation outcomes, or avoided harm, from particular actions is challenging since there may likely be a significant time lag between when actions are implemented and when outcomes are realized. Therefore, initial efforts to track adaptation have relied upon more near-term indices of adaptation (Ford et al. 2013). Such work has mainly focused on analysis of adaptation actions reported in peer-reviewed or gray literature (Berrang-Ford et al. 2011; Bierbaum et al. 2013; Ford et al. 2011). Adaptation readiness (including political leadership, available funding for adaptation, or presence of planning documents) may also serve as an indicator of adaptation progress (Ford et al. 2013). Prior evaluations of adaptation progress have focused on broad-scale adaptation (Berrang-Ford et al. 2011; Bierbaum et al. 2013), but more research is needed to understand whether such indicators are reflective of adaptation at regional or local levels. For example, although Secretarial and Executive mandates require federal agencies to consider climate change in decision making and identify climate change vulnerabilities for public lands, few adaptation projects have actually been carried out (Archie et al. 2012; Ellenwood et al. 2012). Currently, there are limited examples of efforts by natural resource agencies to track progress on adaptation. A new initiative by the USDA Forest Service, the Performance Scorecard (http://www.fs.fed.us/climatechange/advisor/scorecard.html), offers an example of work devoted to tracking the status of climate change efforts across National Forests.

Idealized Adaptation Process: A Framework for Understanding

A systematic understanding of climate change adaptation by local natural resource managers is needed, not only to characterize the current status of adaptation, but also to enhance future efforts to track adaptation at scales relevant to state agencies or regional organizations. Moser and Ekstrom (2010) utilize a rational decision-making model to depict the idealized, intentional adaptation process. This framework can be useful in beginning to characterize how adaptation takes place in practice (Archie et al. 2012). It includes three main phases, along with their various subprocesses: understanding the problem, planning adaptation actions, and managing the implementation of selected options (Fig. 1). For climate change adaptation, activities in the understanding phase typically involve the development of impact or vulnerability assessments and collection of baseline data. Adaptation options developed in the planning stage can include actions targeting natural systems or those aimed at building the adaptive capacity (e.g., securing resources, promoting learning) of individuals and organizations (Adger et al. 2005). Following implementation, monitoring and evaluation can guide necessary adjustments under changing conditions.

In practice, this process rarely occurs in discrete stages and usually includes multiple actors across organizational scales (Sabatier 2007). Therefore, it is important to consider the diverse forms that adaptation may take in different contexts. Adaptation can be classified in terms of the actors involved, the organizational scale reflected in the process,

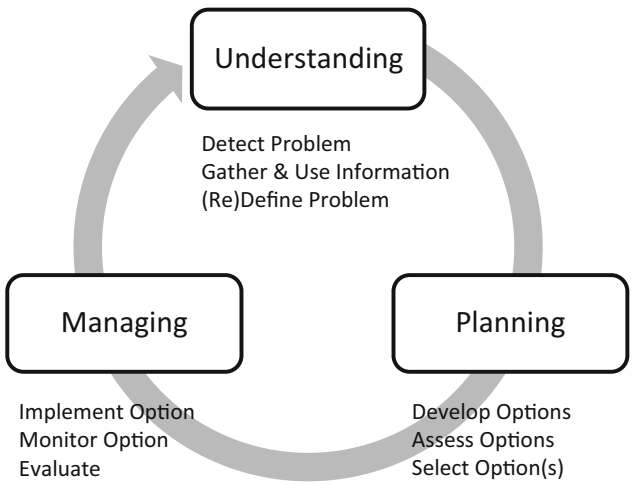

Fig. 1 The adaptation process including three phases and subprocesses. Adapted from Moser and Ekstrom (2010)

the target of adaptation, the spatial scope, and the temporal scale. For example, actions can be taken by individuals, organizations, or broad communities (Adger et al. 2005). Moreover, the scales at which these actions take place are often connected; individual learning is critical to organizational learning, in which organizations identify and use information collected by individuals to improve decisions and actions (Moynihan and Landuyt 2009). Additionally, the adaptation process might be designed to target a single species or broader ecosystems (Stein et al. 2013), and the spatial scope may vary from local to widespread (Smit and Wandel 2006). On a temporal scale, adaptation may involve short-term responses to climate change impacts with the goal of returning to previous conditions, or adaptation can have long-term goals, involving a significant transformation to the system (Kates et al. 2012; Moser and Ekstrom 2010). A systematic understanding of the adaptation process can more clearly illuminate potential barriers and leverage points from which to better support the process (Moser and Ekstrom 2010).

In the Upper Midwest, some coordinated efforts exist to facilitate adaptation among natural resource managers, such as the Climate Change Response Framework developed through the Northern Institute of Applied Climate Science, the Forest Service, and many other partners (Bierbaum et al. 2013). Surveys of managers in the region indicate that a majority feel climate change is already impacting the region (Petersen et al. 2013), but little information is available regarding the degree to which climate change adaptation is actually undertaken by these managers. To better understand the current status of adaptation, we conducted a systematic qualitative assessment of adaptation by field-level land managers from state natural resource agencies in the Upper Midwest of the United States. We asked: (1) How do state public land managers understand, plan for, and manage climate change adaptation? (2) To what degree does the experience of land managers reflect the idealized adaptation process? (3) Are common measures of adaptation progress suitable indicators of adaptation action?

Methods

To address these questions, we conducted qualitative in-depth interviews with state agency public land managers in the Upper Midwest (Michigan, Minnesota, and Wisconsin). The case study, qualitative research framework was chosen due to the opportunity for this approach to provide in-depth, rich information from informants (Patton 2002) and is particularly useful when little is known about a topic. This qualitative approach was appropriate given the limited understanding of the current state of climate change adaptation in the region. Findings from our work can be used to identify future avenues of inquiry and complement quantitative surveys of managers carried out in the region (Martin et al. 2014).

To identify potential participants, we obtained a list of all 348 wildlife biologists and foresters managing public lands. We sought to provide coverage of foresters and wildlife biologists from across the eco-regions found in the Upper Midwest, with 13 of the 14 eco-regions represented by those we interviewed. We recruited participants first by email or telephone and subsequently sent an email to confirm the interview and offered additional details related to the overall project goals, confidentiality of the interview, and their rights as a participant, with survey procedures following the Wisconsin Department of Natural Resources survey manual code. We stopped recruiting and interviewing managers once interviews did not yield substantively new information or themes (Patton 2002).

We conducted the majority of interviews via phone, with the exception of two interviews conducted in-person, between June and August 2013. The semi-structured interview guide was designed to provide an understanding of managers' experiences with, and perceptions of, climate change impacts, efforts towards planning for climate change, and a full range of actions implemented to address climate change. In the semi-structured interviews, questions were open-ended and each successive question was guided by the interviewee response, so that each interview was unique. Example interview questions included:

- What environmental or habitat changes have you already experienced in your region that may be attributed to changing climate patterns?
- To what degree do you or your management unit have a formal or informal plan in place to address climate change?
- What decisions have been made or steps taken to address the top issue impacting your management unit?

Of the 29 interviewees, 13 were foresters and 16 wildlife biologists. Thirteen were responsible for supervising or directing the work of at least one other staff, and most interviewees had more than 11 years of experience in the field of natural resources. Interviews averaged 30 min in length, ranging from 12 to 54 min. With the consent of participants, we digitally recorded interviews. In one case, the participant refused to be recorded, and we relied on the detailed notes of the interviewer. We transcribed interviews verbatim, and a single analyst coded the data using the qualitative research analysis tool NVIVO 10 (QSR International 2012).

Thematic codes were derived inductively and deductively, meaning that themes were developed both as they emerged from the interviews (i.e., open coding) and a priori based on existing literature (i.e., directed coding) (Hsieh and Shannon 2005). Specifically, we identified

adaptation actions by their type or form (e.g., promote diversity, conduct research, restoration) using existing classifications of adaptation strategies from the literature (Dziegielewska 2012; Gregg et al. 2012; Mawdsley et al. 2009). We considered adaptation to be actions that managers explicitly described as connected to climate change impacts and included actions that target natural systems and those aimed at building adaptive capacity. We further classified actions on the basis of their temporal and institutional scales. We distinguished between short- and long-term actions; short-term actions were defined as occurring for a limited period of time, with a clear end date. We also differentiated between actions that were locally led versus those taking place at larger institutional scales. Specifically, locally led actions were considered to be those initiated by the land manager in comparison to actions initiated by others at higher levels within the institution. Themes were developed based upon a set of similar experiences. However, "minority" perspectives were also important to theme development, which is consistent with qualitative inquiry (Strauss and Corbin 1990). Quotes are used to provide examples and illustrate key findings.

Results

We provide descriptions of managers' reflections on their experience around each stage of the adaptation process (understanding, planning, and managing). We then present themes that emerged at each stage including: uncertainty in attempts to understand climate signals; planning as remote from local management; and management actions as forward looking, but also aimed at coping with current impacts. In addition, we introduce a fourth theme related to the overall adaptation process.

Understanding Climate Change Signals

Managers identified a number of climate change impacts in their region. In total, 28 participants (all but one) identified 18 different impacts they perceived as potentially related to climate change, including both primary climate change impacts (e.g., changes in precipitation and temperature) and resulting secondary effects on the natural environment (e.g., prevalence of diseases or pests). In only one instance did a manager mention an impact related to how humans will respond to climate change (e.g., changes in land use). These more indirect impacts have been recently highlighted by conservation scientists as often neglected, but highly important to consider (Turner et al. 2010; Watson 2014). Changes identified by the most participants include invasive species prevalence, increased tree diseases and pests, and variability in precipitation (Table 1). Notably, the two most prevalent climate change signals were secondary effects of climate change.

Uncertainty in attempts to understand climate signals Uncertainty was a common theme in attempts to understand climate change signals. Although the majority of interviewees offered at least one experience they considered to be related to climate change, nearly two-thirds of managers reported difficulty in interpreting those experiences as a direct result of climate change. When asked to identify a climate change signal, these managers typically qualified their responses by saying that they could not be certain the change they identified was due to climate change. Specifically, managers noted difficulty in parsing out climate from other factors which might be contributing to the change they were experiencing on the landscape. Other reasons managers expressed uncertainty were that they questioned whether the change was part of a natural short-term cycle or if it was the result of long-term climate change. Managers also perceived that the time frame over which they have experience was too short to be certain of whether or not the change was climate related (Table 2).

Planning for Climate Change Adaptation

Just under half of managers identified climate change planning processes which were relevant to their management unit. The remaining 17 managers did not identify any climate change planning taking place for their unit, although a sub-set of these managers described plans or actions at the highest levels in the agency, such as the hiring of a climate change coordinator for the state. Of those with locally relevant plans, eight managers described formal or institutionalized planning processes, and an additional four described some form of informal planning. Of the eight formal plans, most involved the incorporation of climate change information into regional planning (i.e., regional state game area plan, regional state forest plan).

Managers described most of these formal climate change planning processes as motivated by existing external requirements, such as certifications or mandates. For example, forest certification programs, including the Forest Stewardship Council or Sustainable Forestry Initiative, set standards for forest management which may require managers to consider climate change as a part of maintaining certification. One forester described these certifications as the driving force behind integrating climate change into regional plans,

> It was primarily driven by the forest certification. Michigan has dual certification…and one of the requirements of certification is that… [climate change] was addressed….It came from [the] direction of the certification process.

Table 1 Climate change signals most frequently discussed by interviewees and number of interviewees expressing uncertainty associated with the signal

Climate change signal	Number of interviewees referencing signal	Number of interviewees expressing uncertainty
Increased prevalence of invasive species	14	6
Increased prevalence of tree diseases and pests	10	3
Extreme or sporadic precipitation events	10	4
Period of drought	10	6
Changes in forest composition	8	4
Mild winter conditions	8	4
Warming temperature	6	3
Tree top-kill or die-off	6	2
Phenological changes	5	2
Increased prevalence of wildlife diseases and pests	5	1

Table 2 Themes that emerged within the broader thematic category concerning uncertainty in attributing impacts and changes directly to climate change trends and examples of associated quotes from interviewees

Difficulty in parsing out climate from other factors	*"We've also had some pretty severe fires in Minnesota….is it due to our climate change or our fire suppression efforts?…That's hard to say"*
	Forester from Minnesota with less than 10 years of experience
	"It's hard to parse those out…..the deer populations have been doing well, but part of that could be improvements or positive changes for them in habitat due to human activity…but I think the climate's also impacting them"
	Biologist from Minnesota with over 40 years of experience
	"It seems like we're seeing more and more invasives and…I think that's more due to just—people are more mobile and move stuff on the landscape…and so in my mind that's not necessarily attributed to climate change"
	Biologist from Minnesota with over 30 years of experience
Natural cycle versus long-term climate change	"*But part of the problem is whether it's a change in climate or just a* 10 *year cycle…*"
	Biologist from Minnesota with over 40 years of experience
	"There has been situations where trees are under stress and have been attacked by pests or either couldn't handle the drought…I'm kind of on the fence for climate change or not climate change. Is this just the climate cycle?"
	Forester from Michigan with 15 years of experience
Time frame too short to be certain signal is related to climate	*"I've seen a lot of changes in this area…there's a lot of variables, certainly climate could be one of them. Even* 33 *years is not a long time to be observing climate-type changes"*
	Forester from Minnesota with over 30 years of experience
	"It's hard to say for sure. I mean, we only live on this earth a pretty narrow window in the first place"
	Biologist from Minnesota with nearly 15 years of experience

Formal planning was described in a single case as specific to a particular property, cooperatively managed with the US Fish and Wildlife Service (FWS). Here, the impetus for incorporating climate change into plans was that it is required under the USFWS model for land management planning.

In the cases where planning was informal, managers typically stated they had considered climate change during the process of assessing options in day-to-day decision making. For example, one biologist, for whom invasive species were considered a climate-related challenge, described the process of selecting an appropriate seed mix for native prairie restoration. He explained,

> It's all informal [at] this time….at the back of my head….and that gets incorporated into some of the decisions we make, but it's not a formal plan by any means….[For example,] we try [to] establish a seed

> mix that is tolerable [to specific chemicals so] when we have invasives come in, we can spray…to kill them but not impact our native forbs.

Planning as remote from local management Planning was often described as remote from local management and emerged as a theme within this stage of the adaptation process. Nearly all formal planning for climate change was taking place at regional levels. Managers typically had the opportunity to either provide input into these planning processes or in rare cases, were a member of the team charged with plan development. Although some planning processes were still on-going, completed plans did not appear well linked to local action. Managers described plans as yet to trickle down to the local level or result in management changes on the ground. One forester from Michigan explained,

> They're just starting to talk just a little bit about climate change in those regional management area plans and what some of those impacts may be, but we still don't have anything specific.

Managing the Implementation of Options

Overall, 26 managers identified 23 different types of adaptation actions across temporal and institutional scales. The most frequently referenced short-term, locally led measures were: shifting resources or priorities; conducting salvage operations; monitoring perceived climate change impacts; and removal of invasive species (Table 3). These actions were typically initiated by individual managers, though actions sometimes also required coordination with others. Adaptation actions at longer temporal and larger institutional scales included: cooperating with others outside the agency; promoting and maintaining forest or habitat complexity; and conducting research. These actions were initiated at higher levels in the organization, with the manager typically playing a more minor role in decision making or carrying out the task. These actions typically involved a more significant adjustment from the status-quo and took more time to complete.

In most instances, short-term, locally led actions were described as being implemented in response to an urgent problem such as a flooding event or disease outbreak that necessitated an immediate need for action. In one case, a manager described how extreme weather, resulting in blow-down events, impacted the forest resource, as well as roads and other infrastructure. The manager responded by shifting resources to conduct salvage operations and address damage to infrastructure. Another manager described actions he took in response to intense precipitation events,

> [We've had a] very high incidence of really high, extreme rain events, so that's influencing us… a greater frequency of flooding issues to have to mitigate and from a management standpoint we basically have to keep doing more of the same…We have to manage [the impoundments] more intensively. We have to visit those sites more frequently, monitoring them.

Management actions as forward-looking, yet coping with current impacts A theme that emerged for this stage of the adaptation process is that while forward-looking

Table 3 Most frequent adaptation actions as defined by their temporal and institutional scales and number of interviewees referencing the actions

Short-term, locally led measures	Number of interviewees referencing action	Measures at longer temporal and larger institutional scales	Number of interviewees referencing action
Shift resources or priorities	12	Cooperate with groups or individuals outside with agency	8
Conduct salvage logging operations	5	Promote and maintain forest or habitat complexity	6
Monitor climate change impacts	4	Conduct research	5
Remove invasive species	4	Modify hunting regulations to manage wildlife disease	3
Communicate with the public	3	Promote learning by staff members	2
Extend time frame for timber sales	3	Increase staff or funding	2
Cooperate with other managers within the agency	2	Make infrastructure more resilient	2
Manage water control structures	2	Manage for species likely to do better under current or projected changes	2

actions have been implemented, a significant portion of management activities are aimed at coping with current impacts. Of the 29 managers interviewed, 17 referenced at least one action that was long term and initiated at higher levels in the institution. The majority of these actions were aimed at increasing system resilience to climate change and could be described as forward looking. No transformative activities (i.e., cause a fundamental change in the social-ecological system) were identified. However, many of managers' activities may be considered "no-regrets" strategies, which align with managers' current plans and activities and provide immediate benefits at limited cost. For example, 20 managers referenced implementing at least one short-term, locally led action, the majority of which were coping measures dealing with current impacts. These actions did not significantly differ from managers' existing responsibilities. Managers described these coping measures as being associated with a number of challenges, most dominantly lack of time or staff. These time-intensive measures, amid other work responsibilities, may impact managers' capacity to plan or implement forward-looking strategies. One biologist in Minnesota described this issue,

> If we're going to actually integrate climate change into something as simple as management plans…we need to have the time and the convenient resources available to us…Otherwise it's going to be pale in comparison to the day-to-day grind such as a land-owner—someone that's got geese taking 5 acres of bean…There is no discretion there. I've got to go deal with that rather than spend the time behind the desk assessing climate change.

The Adaptation Process and Cross-Scale Dynamics

Cross-scale dynamics emerged in managers' stories as an important theme related to the overall adaptation process. Specifically, we identified instances of both feedback and disconnect between adaptation across temporal and institutional scales.

Feedback occurred in some instances where short-term adaptation processes were linked to long-term actions being implemented at higher institutional levels. For example, one biologist described the challenge associated with managing water control structures in the face of flooding events. The events required more time-intensive monitoring, significantly increasing the workload of staff. In addition to dedicating time to the needed monitoring, the biologist recognized the need to rehabilitate under-engineered water control structures and worked to form partnerships and obtain funding to complete rehabilitation (Fig. 2). The thought being that addressing shortcomings in infrastructure may reduce the frequency with which the structures wash out in the future. In this case, redefining the problem to one of more long-term climate change, rather than a focus on individual flooding events, resulted in the implementation of more forward-looking, collaborative strategies.

This pattern of feedback was not limited to managers dealing with a single type of management issue. Addressing an urgent climate-related problem could also change the way managers thought about unrelated areas of their management. For instance, one wildlife biologist described the events surrounding an epizootic hemorrhagic disease outbreak, which is an often fatal, viral disease in deer. In this case, the manager was responsible for tracking the disease outbreak and addressing concerns over deer die-offs and public health. Together these tasks were very time consuming and resulted in the inability to complete other work he typically did during that time period. This disease, new to the area, was clearly linked to climate change in the biologist's mind. As result of this experience, the biologist later made a decision to consider climate change when conducting habitat management work. He utilized climate change projections for the region in order to select an appropriate tree species to plant.

Conversely, we identified situations where there was clear disconnect between adaptation at larger institutional scales and the adaptation processes at local levels. This disconnect was particularly evident between regional planning processes and the implementation of those plans at a local level, which re-emphasizes the theme that planning was remote from local management. For instance, one forester in Minnesota described how climate change had been integrated into region-wide forest plans. The forester had the opportunity to provide input into the planning process, but ultimately the plan did not provide direction as to how the on-the-ground management would be impacted because of a lack of specificity and competing priorities laid out in the plan (Fig. 3). The forester described,

> Certification topics and…goals are drawn into the sub-section plan and in the certification there are climate change components…. there's not priority…there's no specificity to them…they're nothing that would be really helpful at the local level… [for example,] this is what it says we're going to do, and this is how we're going do it. Let's move forward and do it. There is not that level of specificity to it.

Discussion

We utilized a systematic framework to better understand the status of climate change adaptation at the level of local natural resource managers. Specifically, we evaluated how

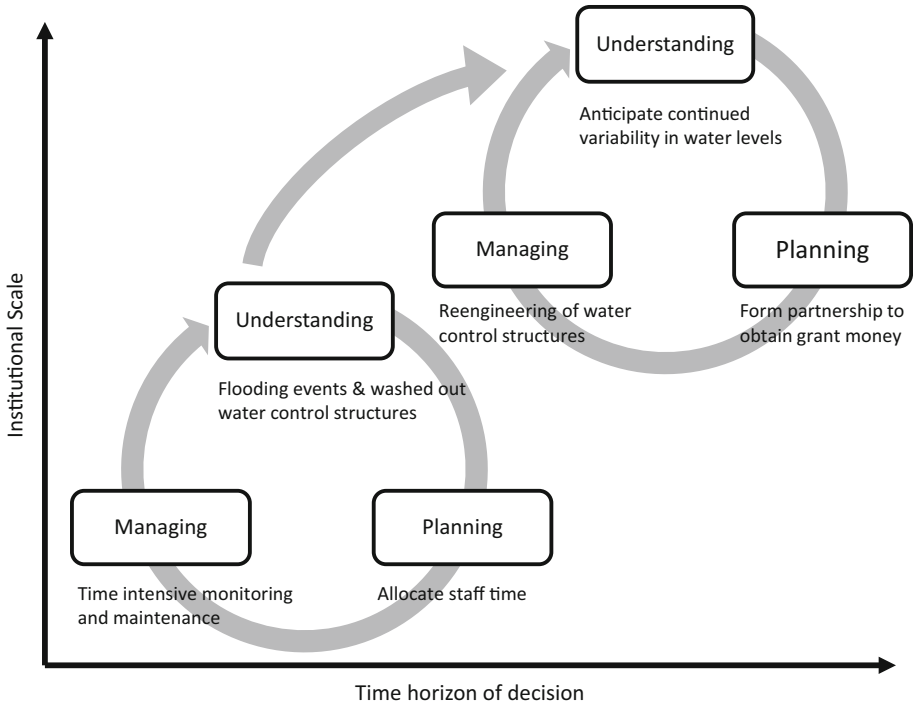

Fig. 2 Feedback between short-term adaptation process and long-term adaptation process through a redefinition of the problem as one of long-term climate change

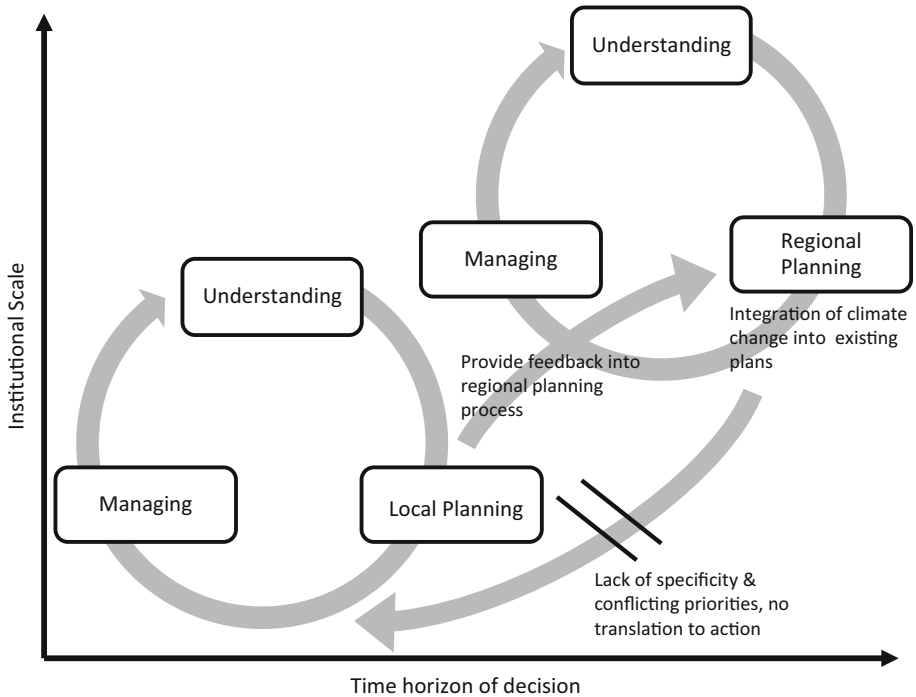

Fig. 3 Disconnect between regional planning processes and on-the-ground implementation

managers understand, plan for, and implement adaptation actions. We found that nearly all managers perceived climate-related changes as impacting their management unit, but also identified significant uncertainty in managers' interpretation of those signals. Just under half of managers were involved in planning efforts and most planning appears remote from local management. Although some forward-looking actions were already implemented, managers were also coping with current impacts. We also assessed to what degree the experience of land managers reflects the idealized adaptation process, and found evidence for both feedback and disconnect between the temporal and institutional scales of adaptation. We discuss the implications these results hold for understanding whether

common measures of adaptation progress are appropriate indicators of on-the-ground action.

Defining Climate Change Adaptation

At the most basic level, a clear definition of climate change adaptation is needed for research and tracking. Definitions of adaptation highlight the importance of intentional adaptation, defined as the use of strategies that are designed with an explicit understanding of climate impacts and vulnerabilities (Stein et al. 2013). However, interviews indicate that many strategies implemented to address perceived climate change impacts do not meet this criterion of adaptation.

Locally led, short-term adaptation actions, typically implemented by managers to deal with an urgent problem, made up a significant proportion of adaptation strategies described by managers. In some cases, these actions do not appear to differ from existing responsibilities and therefore may or may not be considered intentional. In fact, many of the land management actions that are promoted as addressing climate change may be similar to actions already underway (e.g., invasive species management). Strategies may be simply re-labeled as adaptation, but offer no additional avoidance of harm associated with climate change impacts. Further, uncertainty associated with managers' interpretation of climate change signals make it difficult to assign intention to the actions implemented in response to those signals. Managers reacting to a single event express uncertainty in directly assigning climate change as a causal factor; therefore, it is unclear whether actions taken are motivated by climate change. This experience of managers reflects the boundaries of causal scientific knowledge and the difficulty of applying average model results to specific cases (Sarewitz and Pielke 2007).

Intentionality may not always be necessary to get actions that reduce negative impacts from climate change, if an alternative lens for management can also result in avoided harm. Others have suggested that even intentional, planned adaptation can result in unforeseen consequences over the long term that may actually exacerbate the impacts of climate change (Adger et al. 2005).

However, without intentional considerations of climate change, there are no assurances that the desired adaptation outcomes can be reached. We found it was particularly difficult to assess whether strategies implemented were specifically designed to target climate change impacts. Therefore, it may be particularly important that regional or local metrics of adaptation explicitly assess the degree to which strategies are designed around climate information, such as the integration of vulnerability assessments into the decision-making process. Additionally, evolving perceptions of natural resource managers with regards to intentionality and adaptation may, in fact, serve as an indicator of progress. Investments that build the capacity of managers to approach climate change with intentionality, such as trainings or access to resources, may be important in promoting the adoption of effective adaptation strategies.

Planning-Implementation Gap

One indicator of adaptation readiness within an institutional context is the presence of planning documents (Ford et al. 2013). We found that regional, formal plans are not described by interviewees as well connected to management actions on the ground, and therefore suggest caution in the use of existing plans as an indicator that adaptation actions are being implemented at local levels.

Adaptation plans, as described by managers, typically consisted of the integration of climate change information into routine planning processes. These planning processes lay out a more long-term management strategy for a region or property. Therefore, planning may not be initiated by individual managers, but rather part of a larger institutional procedure. Importantly, plans that were completed had yet to impact on-the-ground management, from the perspectives of those interviewed. This is contrary to the hypothesis that integration of climate change adaptation into existing planning processes increases the likelihood of strategies being implemented. Mainstreaming is often promoted as a strategy that supports the adoption of adaptation strategies (Smit and Wandel 2006). However, long-term tracking of adaptation plan implementation is needed to better understand the potential value of mainstreaming climate change into planning processes.

The gap between planning and implementation is considered a common conservation challenge (Biggs et al. 2011). Recent work suggests that factors such as funding, public and institutional support, and the creation of a shared vision are important in closing this gap and improving implementation success (Biggs et al. 2011; Carter et al. 2014).

Utility of a Rational Decision-Making Framework

The rational decision-making framework has been used to characterize how adaptation takes place in practice (Archie et al. 2012; Moser and Ekstrom 2010). Others have suggested that, in fact, the presence of adaptive management components (e.g., reviewing previous research, setting objectives, and considering options) may be indicative of success in decision making for adaptation (Hagell and Ribic 2014). We argue that the utility of a rational decision-making cycle in characterizing or tracking adaptation is limited if issues of concurrent, causal, and cross-scale

dynamics are not addressed (Sabatier 2007; Sabatier et al. 2005).

In assessing the degree to which managers' experience reflect the idealized adaptation process, we found evidence for disconnect between adaptation at different institutional and temporal scales. Formal planning for climate change adaptation typically takes place at upper levels of the agency, and is not well linked to the managers who would be responsible for the implementation of adaptation actions on the ground. This example of a mismatch highlights a common problem associated with cross-scale interactions (Cash et al. 2006).

Interviews also indicate that overlooking cross-scale influences may result in missed opportunities to support organizational learning about climate adaptation (Pahl-Wostl 2009). Our work indicates that the effects of connecting managers' observations to climate can be far reaching. We presented a case in which a manager connected climate change with a wildlife disease outbreak, and this connection importantly encouraged the manager to consider long-term adaptation strategies when addressing other management issues. Our findings suggest that connecting a particular issue to climate change may actually increase an individual's risk perception with regards to the entire system and encourage further action. This example represents a movement towards multi-loop learning, and is representative of organizational change. Changes in organizational norms and routines are demonstrative of multi-loop learning and are linked to an organization's ability to effectively adapt (Pahl-Wostl 2009).

Together, these findings support previous work that asserts individual adaptation actions are not isolated, but influenced by social and institutional processes which take place at other scales (Adger et al. 2005; Smit and Wandel 2006). Hagell and Ribic (2014) found that managers ranked the components of adaptive management as important in decision making, but use of the components was relatively low compared to their perceived importance. Strategies that contend with scale may make a boundedly rational decision-making process more relevant to managers. An example of one such effort is a bridging organization that encourages two-way communication and the co-production of knowledge between different scales (Cash et al. 2006).

While this work speaks more broadly to conceptualizing the evaluation and tracking of climate change adaptation, we recognize various limitations to this work. First, our work was limited to the upper Midwest and adaptation efforts will certainly differ elsewhere because of different ecological, social, political, and institutional contexts. Also, the qualitative approach provided rich and detailed information that aligned with the intent of our research, yet further quantitative surveys would help to provide generalizability of the study findings.

Conclusions

Interviews with managers revealed the real yet ambiguous threat of climate change. We found that most managers perceived climate-related changes as directly impacting their management unit, but expressed uncertainty in interpreting and taking action on those signals. Managers were faced with the time-consuming challenge of coping with current impacts, which conflicted with other responsibilities. Planning for climate change was rarely initiated at the local level and, we found significant disconnect between the temporal and institutional scales of the adaptation process.

Governments and stakeholders are beginning to ask for information to measure agency progress toward climate change adaptation goals. Although some advancements have been made at characterizing and tracking broad-scale adaptation, questions remain concerning which criteria for adaptation reflect the experiences of field-level land managers. Organizations and agencies looking to understand and track progress on climate change adaptation face significant challenges in developing appropriate definitions and measures for adaptation at the local scale. Insights gained through this study are key in taking stock of adaptation now and into the future. We identified the need for a definition of adaptation that is clear with respect to intentionality and the importance of identifying and addressing planning-implementation gaps and cross-scale dynamics in tracking efforts. Ultimately, greater knowledge of the trends in climate change adaptation can assist in evaluating current and future investment decisions.

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