Climate Adaptation in the San Juan Basin: Interviews on Pinyon-Juniper and Seeps, Springs, and Wetlands

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I. Key Findings

As part of the Southwestern Colorado Social-Ecological Resilience Project, twenty-six agency staff from three agencies and eight grazing permittees were interviewed about landscape changes in the San Juan Basin. Interviews focused on changes to pinyon-juniper woodlands (PJ) and seeps, springs, and wetlands (SSW), and on climate change, adaptation and uncertainty in land management. Both agency staff and permittees envisioned changes to these systems in terms of impacts to specific resources (e.g. water and forage) and activities (e.g. recreation). For agency staff from the BLM and USFS in particular, pinyon-juniper was the location for key management activities (e.g. gazing, oil and gas, and recreation) and not managed for specific ecosystem features. Similarly, permittees focused on rangeland conditions and the management of grazing permits in pinyon-juniper. For most of the NPS interviewees, the management of PJ revolves in part around questions about appropriate fire management and different views on how to best conserve the human infrastructure of the park (both contemporary and historic dwellings) and less often to conserve the ecosystem itself. Similarly, BLM and USFS participants suggested that they were unsure of the "natural" state of PJ, questioned what the management goals for the system should be and wondered whether PJ is a "climax" community or one that is encroaching on other communities that are valued more highly (i.e. sagebrush). For all participants, changes to seeps, springs, and wetlands were seen as important and raised concerns about water availability for a range of human uses, including grazing and recreation. Permitees also expressed concerns about long-term drought, the timing of their on-off dates, staff turnover within the agencies, communication with the agencies, and the length of time taken to receive permission to undertake actions related to their permits.

Participants had different views of what climate adaptation might mean in the San Juan Basin. Both agency staff and permittees conveyed that they had a limited capacity to extend beyond current activities and undertake climate adaptation. Limited capacity for adaptation was linked to budget and staffing constraints. In particular, inadequate resources for monitoring translated into a lack of understanding of how the system/resource is changing over time, knowledge necessary to assess the efficacy of adaptation efforts. In the context of uncertainty and incomplete knowledge, agency staff discussed drawing on a broad, interdisciplinary group of specialists to form a more complete picture to inform decision-making. Uncertainty was believed to promote a risk-averse, conservative approach to decision-making within the agencies.

Given these findings, effective climate adaptation on federal lands in the San Juan Basin may benefit from a focus on current management activities that incorporates the need to improve current conditions that will benefit people and wildlife in the face of climate uncertainties.

II. Background

Environmental change is a constant feature of land management within the US Interior West. Fire, drought, insect infestations, and invasive species present pervasive challenges to the management of western lands. Southwestern Colorado is already experiencing higher temperatures, more frequent and prolonged drought, earlier snowmelt, larger and more intense fires, more extreme storms, and spread of invasive species, changes expected to intensify as a result of climate change. These changes put livelihoods, ecosystems, and species at risk.

The interviews described in this report are part of the larger Southwestern Colorado Social-Ecological Resilience Project (hereafter referred to as the SWCO Project). The SWCO Project is a three-year effort funded by the Department of Interior's North Central Climate Science Center, an agency office that provides climate science, information and tools to land and natural resource managers to anticipate, monitor, and adapt to climate change. In the San Juan and Gunnison basins, the SWCO Project works with scientists, land managers, and stakeholders to facilitate the development of adaptation strategies that contribute to community and ecosystem resilience and species conservation, and reduce the negative impacts of climate change.

A diverse group of stakeholders involved with the larger SWCO Project selected adaptation targets for the San Juan Basin in early 2014. An adaptation target is a feature (livelihood, species, ecological system, or ecological process) of concern that sits at the intersection of climate, social, and ecological systems (adapted from Cross et al 2012). SWCO stakeholders chose to focus on two systems, pinyon-juniper woodlands (PJ) and seeps, springs, and wetlands (SSW). Thus, the interviews described below focus specifically on these target systems.

III. Methods

This report is based on 34 in-depth semi-structured interviews with line-officers and specialists from the San Juan National Forest, Bureau of Land Management Tres Rios Field Office, and Mesa Verde National Park, and ranchers with cattle grazing permits on the San Juan National Forest (referred to here as permitees) (see Appendix A for a detailed description of the sample). Interviewees are referred to below as participants. Interviews were conducted in April and May 2014. The interviews were conducted to:

(1) gather information on current use, importance, and status of the targets,
(2) provide insight into current agency decision-making related to the targets and agency approaches to uncertainty, and
(3) identify human communities living within the San Juan Basin that are likely to be impacted by climate induced impacts to the targets.

Interview questions for the agency participants were organized in three sections: current conditions and impacts, future conditions as envisaged under a changing climate, management approaches, capacity to realize goals, and decision making in the face of uncertainty. Agency participants were asked to select one of the two adaptation targets upon which to focus, pinyon-juniper and seeps, springs, and wetlands. Permittee interviews followed a parallel but modified set of questions focused on their operation and allotment, their experiences of changes to the two targets, and their relationship with and expectations of the agencies in the context of change and uncertainty. Below we report the views and perceptions of the interviewees on these topics.

IV. Findings

Perceptions of the Targets and Current Conditions

The two targets present very different adaptation challenges for the agencies. SSW are small, site-specific resources that provide critical water for vegetation, wildlife, livestock, and people in an arid environment. Because water is a limited but highly valued resource, there is significant conflict surrounding the status and use of SSW. In addition, baseline understandings of surface-groundwater connections are lacking, which means knowledge of how SSW will be impacted by climate change is limited. In contrast, PJ is a ubiquitous habitat that covers 19% of the basin and serves as the 'stage' or place where many of the management activities occur, including mining and grazing on BLM and USFS lands, and recreation and cultural resource management on all federal lands. While PJ is widespread, it is not often highly valued for its ecological qualities. PJ also is not typically viewed as vulnerable to climate change. Interestingly, most participants discussed the targets in terms *of what they provide* (e.g. water, forage, recreational experiences). Few participants focused on the value of SSW and PJ in and of themselves.

> *I just don't think we really focus on that PJ community in the direct [way] that you're focusing on it. We've really never had to ask these questions from that perspective. We operate, at least in BLM's world, on an extensive pinyon juniper habitat, and we never really look at the specifics of that declining habitat. (USFS/BLM)*

Responses regarding the importance of PJ were complex. While people recognized the value of PJ for wildlife habitat and as a component of the region's biological diversity, they were somewhat confused about the "value" of PJ itself. This confusion stemmed from the ongoing debate about whether PJ is a desirable "climax" community or a problematic "invasive" community that is encroaching on the landscape. Lack of concern over changes and impacts to PJ were connected to many participants' ideas about its resilience and role in the landscape. Many participants suggested that PJ was quite resilient to change. However, a small minority of participants argued that PJ was in fact vulnerable to climate change, citing recent scientific studies demonstrating how changes to PJ impact PJ-dependent species. To the extent that participants saw PJ as "invasive," they were less concerned over impacts to or declines in the PJ ecosystem. At the same time, some participants mentioned that the recent *Ips* beetle outbreak had made them see that PJ may not be as resilient as they had once thought. Agency staff were spilt as to

whether or not their constituents would 'notice' if PJ changed, with some agency staff wondering whether grazing permittees would prefer less PJ (due to a perception that forage would increase if PJ decreased) or whether recreational users could distinguish a "P from a J." Despite the lack of concern many participants expressed regarding the PJ, many acknowledged that PJ is an iconic feature of the Southwest landscape. This aesthetic value of PJ was emphasized by NPS staff who discussed the value of PJ to the cultural and ecological landscape of Mesa Verde. Some participants talked about pinyon nut collection; however, they reflected that it was not as significant in this area as in other parts of the Southwest.

In contrast, there was widespread agreement that SSW were vulnerable to change. For SSW the primary goal driving all three agencies and the permittees was to maintain current function and ensure water availability for various social, cultural, and ecological uses. Many cited concerns about anticipated water shortages that would impact the entire community and increase the potential for conflict. Despite agreement about the vulnerability and value of SSW, many participants felt that they were largely powerless to do anything about the drivers of change (e.g. the amount of snow and rain).

It is important to note, again, that for both SSW and PJ, most participants largely expressed concerns about the resources derived from and the activities taking place in these systems, rather than concerns about impacts to the systems themselves. In other words, most participants situated climate change impacts within a local, human context by focusing on the specific goods and services that each target system provided, as opposed to changes to specific ecological features of the target system.

Impacts to Permittees and Local Communities

Participants discussed how different climate impacts to the targets effect different groups of people depending on their relationship to the resource. For example, people or institutions whose livelihoods depend on access to public lands (e.g. grazing permittees and hunting outfitters) and with rights to water that flows off the public lands were seen as particularly vulnerable to changes to SSW and PJ. These groups were viewed as directly impacted.

For both targets, permitees were most frequently identified as the primary human community impacted by change given their dependence on both water and forage. However, some agency staff and a few permittees suggested that declines in PJ would be beneficial for ranchers due to increases in available forage. But others questioned whether forage would increase given predicted increases in drought, fire, and invasive weeds.

The permittees themselves expressed very little concern for the specific target systems. Approximately half of the permittees had PJ on their allotments, but they were not concerned about changes in and impacts to PJ. In fact, they were somewhat perplexed the PJ had been selected as a system of concern. Most permittees had stock ponds, fed from

> *Generally the biggest complaint I have with the Forest Service is, many times their only answer is, the cattle, cut numbers or cut time. And that's not the only answer. There's reseeding, finding new water sources, pasture rotations different, but their first focus is—what they can control is the cattle, but they can't control drought, four-wheelers, they can't control any of that stuff. They don't have any law enforcement. (Permittee)*

either developed springs or runoff, and a handful also had some wetlands on their allotments. Major concerns for the permittees revolved around water availability, the timing of their livestock on-off dates, high staff turnover within the agencies, and channels of communication. Most reported having good relationships with the agencies. However, all emphasized a need for open communication, more advance notice of changes to their permits, and a greater respect for local, historical, and experiential knowledge. All of the permittees reported that small changes to their animal unit months (AUMs) and the timing of their on-off dates had significant impacts on their operations. All said that being held off at the beginning of the season had a far greater impact than having their season cut short in the fall because it is easier to find forage for cattle in the fall. The limited availability and fragmentation of private land within the San Juan Basin contributes in significant ways to the vulnerability of the permittees because it is difficult to find affordable private grazing land to lease.

Some participants discussed secondary or indirect impacts that would emerge as a consequence of these direct impacts. For example, if permittees were impacted economically, they might spend less money in local communities which would create ripple effects on other businesses and community members. Water use and availability upstream might impact downstream users. Ecosystem changes might impact landowners in the wildland urban interface (WUI) due to changes in fire regimes. Some participants also mentioned aesthetic changes in the landscape. For example, in reference to Mesa Verde, a handful of participants talked about the intangible or symbolic impacts associated with the loss of ecological communities. While interview participants identified community members who might be affected by changes to SSW and PJ, the focus of the interviews on ecosystem targets meant that a broader understanding of how climate change might impact people in the San Juan Basin was beyond the scope of the research.

Management Goals and Challenges

Beyond the broad mandates that the agencies have to "maintain and improve condition" and "minimize the impact of disturbance" (BLM and USFS) and "cultural and natural heritage preservation" (NPS), most participants did not identify specific management goals related to either of the targets. This was particularly evident relative to PJ because many participants were not managing PJ specifically, but rather managing activities in PJ. This is consistent with the finding described above, that most participants focused on PJ as a place or location for a set of valued activities that they manage, rather than an ecological system that they manage for valued ecological benefits.

The agencies identified similar management challenges in relation to the two targets (Box 1). All participants reported a substantial lack of capacity to undertake the management they believed necessary to meet their goals, particularly in the context of climate change. Lack of capacity emerges from the usual challenges: insufficient budgets and personnel (e.g. both BLM and NPS participants

> *I believe the agency has the capability of holding its own. I'm not sure the agency has the capability to advance protection, but what is protection? Does protection mean hands-off? Natural processes dominate? How do you factor in, then, natural processes that might have a poor effect? In general I would say the agency has that ability. It's a struggle, but it's a struggle that exists with everything we do. (USFS line officer)*

discussed declining specialist expertise) and a lack of capacity to undertake relevant monitoring. Many participants saw this lack of capacity as constraining their ability to respond to change, both now and in the context of climate change. Many participants reported that additional resources and staff would enable them to achieve current management goals. Participants explained that while they might have the capacity to maintain current conditions, they lacked the capacity to further protect or restore, or to mitigate the impacts of large scale change. Finally, because the agencies did not have specific management goals for PJ, some participants were unable to comment about their capacity to achieve specific goals in this system.

Box 1. Management Challenges Identified for Two Targets

Seeps, Springs, & Wetlands	Both	Pinyon-Juniper Woodlands
• Drought • Overgrazing • Lack of baseline knowledge (i.e. location and condition) • Increased demand for water	• Limited budget & personnel • Invasive species • Restoration • Sensitivity to disturbance	• Soils sensitive to disturbance • Fire dynamics • Interactions between fire and invasive species • Fragmentation in the wildland urban interface (WUI) • Travel management

Monitoring and Sources of Information

Agency staff reported varying degrees of confidence in the knowledge they have to adequately manage the resource. Agency specialists were the most frequently cited source of knowledge, followed by experiential knowledge from within the agency and local communities. Academic networks and the scientific literature were less frequently mentioned. Despite this, many discussed an increasingly reliance on external networks for expertise, particularly with regards to managing the effects of climate change. Participants expressed similar needs for additional knowledge across the agencies (see Box 2).

Box 2: Additional Knowledge Desired

Seeps Springs Wetlands

- Inventory and evaluation of current status
- Response rates to drought
- System function and groundwater connectivity
- Wildlife use data
- Connections between natural and cultural resources (NPS)

Pinyon-Juniper

- Fire regimes
- Appropriate fire mitigation
- Successional dynamics
- Cumulative impacts

Both

- Climate impacts over next 10 years
- Management for long-term drought

Monitoring varied across the agencies and participants differed in their perceptions regarding whether the current monitoring efforts are adequate. For the BLM and USFS, monitoring was almost always driven by external requirements – documenting project impacts or meeting legal mandates – rather than monitoring the specific condition of the targets. Conversely, the NPS Colorado Plateau Inventory and Monitoring Network were monitoring PJ and SSW in Mesa Verde with a focus on the impacts of climate change. Given the lack of direct monitoring of the condition of targets, many suggested they did not have adequate baselines on the condition of these systems. The USFS has two data sets on the condition of some SSW. However, many participants believed monitoring could be substantially improved. Across all agencies, poor inventory of the current condition of SSW was readily reported as a constraint on management, as "you can't manage what you don't know."

> *Maybe we know about 60% of the seeps and springs. It'd be great to have the time to get the other 40%. The problem is that the work we do tends to be driven by an environmental assessment for a grazing allotment or a water rights case. There's reasons why we get the data. We kind of drift with whatever's most compelling to collect. We don't have the luxury of just going to do it for the sake of doing it. There's usually so much work that there's a reason why we're doing it. It leaves holes in the landscape. (USFS)*

Climate Change and Adaptation

Agency participants uniformly characterized climate change as bringing hotter and drier conditions to the San Juan basin and mountains. Some spoke of interacting effects with other stressors (e.g. fuel build-up, invasives, grazing, fragmentation) and the cascading impacts of climate change in the region. All believed that a hotter, drier climate would drive declines in the condition of SSW. However, some also pointed to the differential impacts in relation to drought (e.g. recent droughts demonstrated that some SSW were more susceptible to drying up than others). For PJ, responses were more mixed, with the majority believing that PJ would expand due to climate change, moving up in elevation. NPS staff and a handful of USFS staff discussed the potential for more dramatic changes to PJ. However, most participants did not discuss the potential for PJ to disassociate or completely transform.

The majority of agency participants perceived climate change to be a significant challenge for the future. A handful of agency participants questioned whether there was complete scientific certainty regarding human-caused or anthropogenic climate change, with one participant reporting outright skepticism. Permittees perceived climate change to be driven by natural cycles, something that has always been happening, and questioned whether human activities were driving local landscape change. Many permitees did, however, report noticing changes in the area over the duration of their lifetime, which they attributed to cyclical changes in the climate.

Participants expressed different views about the ways that climate change influenced agency management. Many participants reported a general sense that climate change would influence planning but little specific detail regarding how that might happen. Climate change was explicitly considered within the Mesa Verde fire management plan (which is a significant driver of PJ management at Mesa Verde) and the jointly authored USFS/BLM Forest Plan/Resource Management Plan. However, participants stated that climate change had not yet influenced or

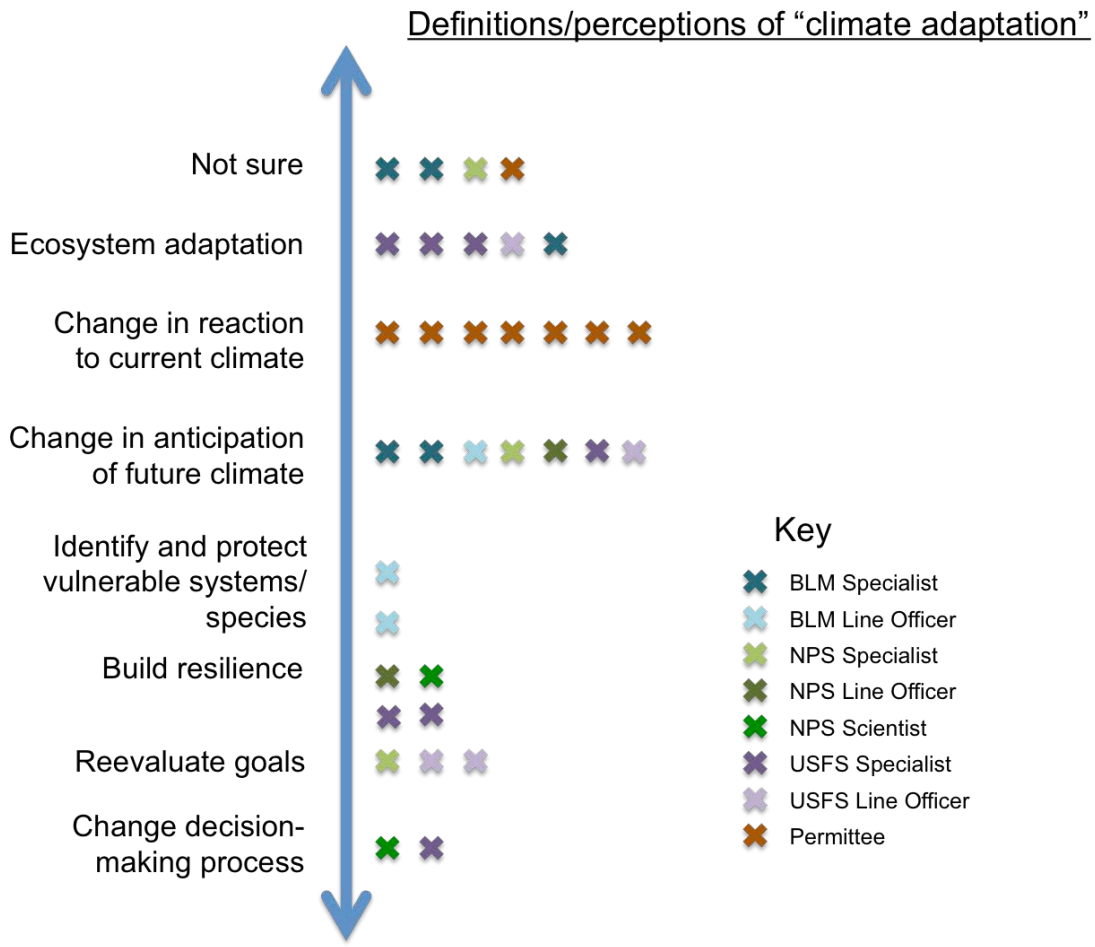
> *The thing that people really respond to is some type of fiat. There's good things and bad things about that, but if there was more of an emphasis on climate change at the level of project-level decision-making, then I think over time… we start getting our heads around. But right now I see it as something that's been, "Deal with it if you feel like you've got the understanding at your level. If you don't deal with it, you'll get a pass." Our feet haven't been held to the fire, so to speak, on addressing climate change in our analyses. (USFS Line Officer)*

changed the management of SSW. Few agency participants mentioned specific policy directives related to climate change or adaptation in relation to how they manage the targets. However, many line officers reported "needing to deal with" climate change in management decisions. Participants across all three agencies repeatedly emphasized the need to be realistic about what can actually be achieved within the current capacity of the agencies across diverse topics from current management of the targets to any future adaptation strategies.

When asked what climate change adaptation meant to them, participants expressed a range of views. A handful of agency staff and all of the permittees were unfamiliar with the term (see Figure 1). A number of USFS staff responded by describing the ways that ecosystems or species change or adapt in response to climate change and were uncertain how the term might be applied to agency management or decision-making. The participants who did connect adaptation to decision-making focused on the ways that they would recalibrate what they currently do to match future climatic conditions. Very few participants discussed the ways that adaptation might require changing the way decisions are made. Given uncertainty about the meaning of climate change adaptation, some BLM and the USFS suggested that they needed more specific directives from their agencies to define adaptation and how they would be expected to implement it. In short, very few participants envisioned that adaptation might require changing the decision-making processes or management goals or objectives. Rather, most saw adaptation as simply recalibrating what they do to match the future climate of the region.

These different perceptions of adaptation will likely have implications for the ways in which agency staff and permittees respond to different adaptation strategies proposed in later stages of this project (e.g. workshops). This suggests that some time could usefully be spent in later workshops discussing the various dimensions of adaptation (e.g. adaptation strategies related to resistance, resilience, and transformation) as well as the more procedural aspects of adaptation (e.g. building capacity to undertake actions or changing the way that the agencies currently make decisions).

Figure 1. Definitions and perceptions of the term "climate adaptation" from the question "What does climate adaptation mean to you?"



Managing for Ecological Change

When it came to managing for increasing rates of ecological change, participants talked about a need to "get ahead of the change" to be out there on the land to get an understanding of how the resource is changing, and to have good information and monitoring data upon which to base their decisions. Many reflected on the time it takes for the agencies to make decisions and expressed concerns that long decision timeframes would be a barrier to responding to change. A handful of participants spoke about the need to acknowledge that change is the new normal and from that there is a need to adapt decision-making processes to be more effective in dealing with change. Suggestions regarding how to adapt decision-making processes involved streamlining NEPA and having clear policy direction from Washington as to what was expected from agencies in addressing climate change.

Scenarios that provide a picture of the range of different possible futures land managers may face are increasingly being promoted as a mechanism for decision-makers to deal with uncertainty. As the SWCO Project has adopted this approach, the interview guide included a question about whether managers could envisage managing for a range of possible futures.

For us, we have over 100 species that we have to take into consideration. To try to manage for not only that, but multiple climate scenarios, future desired conditions, really, it sounds good, but in practicality, what you would say would not be accurate. (USFS)

I don't know how you'd do that. Presumably there are two different management actions you would need to take if you are needing to manage for the threat of a hotter, drier climate, you're gonna take one management action. If you're managing for a wetter, colder climate, you're gonna take another management action. You can't take 'em both. (BLM)

It would be possible. It would take some more effort to get a few more folks in and more resources focused on that. (NPS)

Responses to this question varied widely, with some suggesting that a scenario based approach was the direction they could see the agencies headed, others suggesting that it was a good idea in theory but would be far too complex in practice, and still others who said they would manage for the average or the worst case scenario. Responses to this question highlight a need for greater communication around what scenario-based decision-making is, as responses suggested that participant understanding of managing for a range of possible futures is very different from approaches promoted in the academic literature. Conversely, responses also suggest that the academic discussion of scenario approaches would benefit from greater input from the intended users. Given the additional analysis burden that comes with assessing actions in light of a number of potential futures, the utility of a scenario approach must be questioned in light of existing critiques suggesting that decision-processes are already overly time consuming.

Climate change may result in transformational change to some of the ecological systems that these agencies managed. Participants were asked whether they felt their agencies were prepared for such transformational change and whether they believed there was a role for the agencies to assist these types of transformations. The majority of participants believed that their agencies were not prepared for such change, citing slow responses to any kind of change, institutional inertia, and the attachment that individuals within the agencies and the general public have to particular systems being in particular parts of the landscape.

No, I think we're pretty resistant to it… we don't like pinyon juniper encroaching on the sagebrush. We don't like tree line moving into the alpine…but we don't necessarily do things about it, either, because we don't have the capacity. (USFS)

I don't know if we're prepared or not. If that's what's happening, it's going to come, and there's not a whole lot we can do to change it. (NPS)

The majority of participants believed that the agencies do have a role in assisting transformation, with many from the BLM and USFS suggesting this is simply an extension of their current active management. For the NPS, this question raised issues related to the agency mandate and the appropriate role of active intervention in the ecological systems they manage. However, all NPS participants reported that these issues were being actively discussed within the agency. The NPS participants discussed intervention in transforming systems more in relation to minor interventions designed to prevent the negative impacts of change, such as shifts in the management of fire or invasive species rather than broad scale changes like revegation using different species adapted to future climatic conditions.

Management in the Face of Uncertainty

Making adaptation decisions requires agencies to plan and act in the context of various types of uncertainties. Thus, a critical component of adaptation requires understanding how agencies negotiate uncertainty in decision-making. Agency staff and permittees uniformly suggested that uncertainty does not prevent them from making decisions. As one BLM specialist suggested, "ultimately, a decision has to be made." However, they all suggested that uncertainty makes decision-making more challenging.

> *Working in the context of uncertainty is something that the agency is very capable of, because we do it all the time. We never have complete information, I don't think. (USFS, Line officer)*

Despite perceptions that agency decision-making processes can deal with uncertainty, some interviewees suggested that NEPA processes do not adequately incorporate uncertainty because analyses assume that knowledge of past actions can inform future actions which limits considering how conditions will change in the context of climate change.

Further, while incomplete knowledge did not prevent the agencies from making decisions, the absence of more detailed information about climate change was viewed by some as a barrier to action. Without more accurate information about climate impacts, people suggested that management would be a continuation of the status quo. More specifically, they argued that they would likely continue to "muddle through" and assess impacts where they could, or use their professional judgment, make conservative decisions, and then monitor and adjust. Agency staff commonly referred to the importance of professional judgment and engaging a broad group of experts when there is incomplete knowledge. Many talked about "doing the best they could" with available data, bringing together different types of expertise to gather as much insight into the issue as possible, using professional judgment, and the need to be clear with the public about what they did or did not know within the NEPA process. In particular, they described drawing on various specialists with expertise relevant to a problem to try and compile as complete of a picture as possible.

Many suggested that incomplete knowledge drove more conservative decision-making, as line officers were unwilling to take risks. Line officers suggested that they would be less inclined to "go out on a limb" as they "didn't want to be on the chopping block" for a decision when there was incomplete knowledge. A risk-averse culture, what people commonly referred to as taking a "conservative approach," was common across all three agencies. For the USFS in particular, concerns about litigation seem to motivate conservative or risk-averse decision-making.

> *The Forest Service, I guess you could think of it as being gun-shy. We've been sued and litigated, and we're trying to avoid that, so we put all these impositions on ourselves to try to avoid litigation. (USFS specialist)*

> *Let's assume that we're going in a particular trajectory management-wise, in a certain direction, and that instead of making a radical change in any particular direction, we would make a slight adjustment or multiple slight adjustments and hopefully adapt based on the results of monitoring. (NPS)*

When asked how they believed the agencies should make decisions when they do not have complete knowledge, permittees also suggested that a conservative approach was appropriate, and, similar to agency staff, discussed the importance of different types and sources of knowledge. Permittees spoke at length about the importance of local and experiential knowledge gained from observation of the landscape and the impacts of change. They viewed the incorporation of experiential knowledge into decision-making as necessary to their acceptance and support of management decisions. All permittees questioned an over reliance on scientific knowledge in management decisions and, while they believed science was important; they suggested that the agencies needed to draw on a broader knowledge base. While these sentiments echo the emphasis of the agency staff on a the importance of a broad set of knowledge, it is important to note that knowledge about *future* climate impacts gained through modeling is fundamentally different from the type of *historical* and *observational* knowledge that the permittees believed to be so valuable. For the permittees, *observed* trajectories of change are important to justify adaptation. This indicates that the agencies may face challenges when communicating to different stakeholders about decisions made in anticipation of future climate impacts.

These different perspectives on the standards of proof needed to support management changes are a potential source of conflict between the agencies and their constituents with regards to climate adaptation. The permittees suggested that they would be willing to accept reductions in numbers of livestock or grazing days in cases where the agencies demonstrated "hard evidence" of impacts. Many suggested that the agencies focused too heavily on available forage as an indication of when they should be on the range, arguing that water availability is a more important factor. Permittees also spoke of decision-making processes that would make them more willing to accept restrictions. Concerns included a need for better communication, consistency in staffing, early warning about potential restrictions, and the sharing of responsibility between the agencies in relation to the risk associated with decision-making in the context of uncertainty.

> *If something's happening that requires attention and you can get together with the Forest Service and make a plan together, and it fails, then you're both at fault. If it works, you're both credible. So if the Forest Service comes up with a plan and they leave the permittee out, that doesn't work. If the permittee comes up with a plan and they leave the Forest Service out, that doesn't work, either… I don't need proof, I need cooperation. (Permittee)*

Adaptive management was regularly invoked as a mechanism to deal with uncertainty, although perceptions of how effectively the agencies were currently implementing adaptive management varied. Many suggested monitoring was inadequate and that the process for going back to change a decision was time-consuming and cumbersome. In this context a number of participants discussed a need to "streamline" NEPA processes, although few provided details regarding how this might be achieved. Given limited resources for monitoring of both SSW and PJ, and thus limited knowledge of how climate change is affecting these

targets and about the efficacy of management actions, adaptive management efforts may be challenging. Further research is needed to understand whether and how monitoring efforts can be tailored to include information that could support adaptive management regarding climate impacts and adaptation strategies.

> *Professional opinion, professional judgment. That's kind of where we are right now in how we're addressing climate change… we know that it's happening, we know that we are sensitive to that fact, but we can't address it…All you can say is that we know it exists, but we have no data… that's in my personal opinion why the adaptive management thing doesn't work in trying to apply it to climate change,... It's easy to say, "We'll just use adaptive management. We'll monitor and modify." But what are you monitoring for? What specifically are you monitoring for to see that it's a function of climate change and not of overutilization or standard regional climate? Or if it's something bigger? That's the thing I struggle with. (USFS)*

V. Conclusions

Based on interviews with 34 agency staff and permittees, we found the following:

- There was widespread awareness about climate change and recognition that climate change would impact target systems and that these impacts needed to be addressed. However, most participants felt challenged to effectively deal with climate impacts, due to limited resources and knowledge, and uncertainty.
- The focus on ecological targets enabled in-depth discussion of particular systems and insights into how management agencies and permittees think about and manage these systems. However, this focus did not produce detailed understanding of broader social vulnerabilities as they relate to climate change.
- The focus on targets did enable us to uncover a critical disconnect between the adaptation literature and the way agencies actually manage public lands. In short, most agency management addresses specific activities that occur within ecosystems (e.g. grazing, recreation, forestry, fire management) rather than specific ecological targets within those systems.
- Thus, for adaptation within SSW and PJ in the San Juan Basin to be effective, it needs to wed the agency emphasis on activities and the adaptation focus on ecological values. One way to do so is to focus adaptation on existing management actions by integrating adaptation strategies into current management activities. Such an approach would:
    - Leverage existing resources. All participants expressed concerns about their lack of capacity to pursue additional management activities related to climate adaptation. Integrating adaptation into existing management activities (e.g. range management, silviculture, etc.) might provide a mechanism to leverage existing resources and increase overall capacity for adaptation action.
    - Nest the emphasis on vulnerable species and systems within programs and monitoring that have already been prioritized. There was widespread agreement that agencies do not manage for the ecological values of PJ or SSW per se, but rather focus on specific management activities within these systems, with an

understanding that these activities influence ecological processes and individual species. Further, improved monitoring was seen as critical for effective adaptive management.

  - Resonate with the public and key stakeholders. Federal agencies will likely find more support for adaptation actions if these actions are meaningful to local community members. A focus on the uses and values of the landscape that people care about may help build support for adaptation.

- Efforts to prepare federal land management agencies for climate adaptation may also need to consider the following:

  - Effective responses to climate change may require that the concept of climate adaptation be well-defined and mainstreamed in the agencies. We found that agency staff had very different definitions of climate adaptation and many participants were uncertain about the relationship between adaptation and land management.
  - Adaptation efforts need to be cognizant of the ways that uncertainty influences agency decision-making. Agency staff are accustomed to dealing with uncertainty, but tend more toward conservative, risk-averse strategies and longer decision-making processes as uncertainty increases.
  - Climate change may drive system transformations in some places, but many agency staff are just beginning to consider the possibility of transformative change.
  - The notion of managing for a range of futures is not yet well-established in agency decision-making. It is important to provide useful information about how scenarios and other tools can be used to consider different possible futures and integrate uncertainty into management decisions. At the same time, efforts to integrate new processes such as scenarios into decision-making need to consider the increased analysis burden.
  - More work is needed to determine how to adapt decision-making processes to enable more nimble management. In particular, lengthy decision timeframes and NEPA processes may present barriers to effective climate adaptation.
  - Agencies and different stakeholder groups, such as permittees, may benefit from dialogue regarding the types of knowledge integrating into decisions and the burden of proof required to shift management approaches in the context of change and uncertainty.
  - Dialogue processes that enable managers and stakeholders to share knowledge might also help address disagreements regarding the value and vulnerability of PJ. Building a common understanding of the ways that climate change potentially impacts PJ may be important to adaptation efforts in response to changes in this system.

Appendix A: Interview Sample

The interview sample included 26 agency staff and 8 permittees (all ranchers with grazing permits on the San Juan National Forest). The agency staff included 11 Forest Service staff, 7 Park Service staff, and 8 Bureau of Land Management staff. Nine line officers and 17 specialists were interviewed. Specialists included staff focused on planning, wildlife, range, forestry, hydrology, air quality, climate change, recreation, renewables, non-renewables, natural resources, fire, inventory and monitoring, and NEPA. Four interviewees worked with more than one agency.