Public land manager decision-making in East Jemez under ecological transformation

Frijoles Canyon, Bandelier National Monument
Source: NPS

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I. Executive Summary

Climate-driven ecological transformation characterized by dramatic and irreversible shifts in ecological communities is challenging traditional land management strategies. A growing body of research and technical assistance is emerging to address ecological transformation. One example is the development of the Resist, Accept, Direct (RAD) framework which outlines three distinct land management options in the face of climate change.

The resist option allows for managers to resist specific climate impacts and maintain natural and cultural resources within what land managers have historically defined as the "desired conditions." The accept option allows managers to accept ecosystem changes and alter their strategies to work within a changing environment. The direct option allows park managers to guide "change toward a specific new state because it is feasible to steward change toward a more desirable outcome than what would be achieved with acceptance" (NPS, 2021). Despite the development of this robust framework to address ecological transformation, there has been insufficient focus on social, cultural, and institutional factors that play an important role in shaping managers' decisions when faced with ecosystem transformation.

This project empirically examines decision-making processes that U.S. Forest Service (USFS) and National Park Service (NPS) land managers in East Jemez, New Mexico use to select land management strategies and develop new methods for navigating ecological transformation. East Jemez was selected as a case study site as it is experiencing the fire-driven ecological transformation from forests to grassland and shrubland. East Jemez is facing land management challenges associated with the transformation. Through semi-structured interviews with 19 state and federal land managers, this study examined two questions: **how do natural resource managers make land management decisions and determine future desired conditions during ecological transformation? How does this process vary between different land management agencies, in this case, NPS and USFS?**

Based on the qualitative analysis of the data collected through interviews with land managers, key findings fall into four categories:

- General perceptions of the RAD framework,
- Internal factors that influence decision-making,
- External factors that influence decision-making,
- Barriers to responding to ecological transformation.

This report offers recommendations to agencies and agency staff for addressing barriers to responding to ecological transformation, including establishing and communicating agency land management guidelines under ecological transformation, supporting more collaboration through partner groups, and developing protocols to ensure key partner relationships are not affected when there is personnel turnover. Detailed findings and recommendations are outlined on the following standalone page.

Categories	Findings
General perceptions of the RAD framework	1. Most land managers are open to all three RAD management options. 2. Resisting ecological transformation is the most widely accepted land management option. 3. Most land managers view accepting ecosystem transition, at least in some areas, as inevitable. 4. A small minority of land managers had an aversion or a conservative approach towards accepting transformation. 5. Some managers are resistant to "directing" change.
Internal factors that influence decision-making	1. Land managers expressed forests are valuable to them on a personal level. 2. Managers expressed that they have a moral imperative to manage land for cultural uses. 3. Land management practices ingrained from formal training guide decision-making.
External factors that influence decision-making	1. Agency norms and guidelines influence manager decisions. 2. Public safety is a key consideration when selecting which RAD option to pursue. 3. Ecological factors including protecting threatened and endangered species habitat, maintaining ecosystem services, and supporting biodiversity influence land manager decision-making. 4. Logistical factors, including feasibility, capacity, and effectiveness, influence decision-making. 5. Maintaining and conserving forests for recreation influences manager decision-making.
Barriers to responding to ecological transformation	1. Scientific uncertainty poses a challenge, especially when considering the "direct" option. **Recommendation: Establish and communicate agency land management guidelines under ecological transformation.** 2. Slow agency responsiveness can be a barrier to making effective land management decisions in the face of ecological transformation. **Recommendation: Support more collaboration through groups like East Jemez Landscape Futures.** 3. Personnel turnover poses a barrier to building lasting relationships and networks with other agencies, tribes, and the local community. **Recommendation: Develop protocols to ensure key relationships with tribes, the local community, and agency partners are not affected when there is personnel turnover.**

II. Introduction

Climate-driven ecological transformation is characterized by dramatic and irreversible shifts in ecological communities and challenges traditional ways of managing natural resources. In the past, land managers have favored conservation and resistance to ecological change to maintain ecosystems in their historic states. The idea of conserving land in its "natural" state has largely contributed to this resistance to change. However, in the face of climate-driven ecological transformation, resistance to change may not be feasible and land managers must increasingly consider a suite of land management options that more readily include adapting to and directing ecological change (Cole and Yung 2010).

The Resist, Accept, Direct (RAD) framework was developed by an interagency working group to conceptualize land management options in the face of climate change. A recent Special Section of *BioScience* exploring the RAD framework outlines a research agenda in which exploring how managers make decisions in the face of ecological transformation is a key question (Crausbay et al., 2021).

This project empirically examines the decision-making processes that U.S. Forest Service (USFS) and National Park Service (NPS) managers in East Jemez, New Mexico use to choose from the three RAD strategies and develop new methods for navigating ecological transformation. Through interviews with state and federal land managers, this study aims to examine two questions: how do natural resource managers make land management decisions and determine future desired conditions during ecological transformation? How does this process vary between different land management agencies, in this case, NPS and USFS?

East Jemez will be used as a case study site as it is experiencing ecological transformation and facing the associated land management challenges. Over the past several decades, large sections of the East Jemez mountain region in New Mexico have transformed from conifer forest habitat to shrubland and grasslands, largely due to increasing drought, severe fire, and post-fire flooding (Stortz, Haffey, Kimball, 2017). The 300,000 acres of land in East Jemez is managed by a variety of stakeholders, including Los Alamos County, private landowners, several Pueblos, the USFS, the NPS, and the Bureau of Land Management (BLM) which poses additional coordination challenges (Lehnert, Haffey, and Stortz, forthcoming).

Managers in the East Jemez region are already seeing significant landscape transformation and are facing an important ecological window for shaping land management responses. The choice of land management options has important consequences for the ecology and future of the East Jemez and the people who use, live in, and rely on the area.

This project will serve as a case study to help continue to develop a framework for climate adaptation decision-making on public lands and better support natural resource manager needs. The results from this project can serve as a baseline for understanding how land managers are thinking about land management decisions and how decision-making differs

between agencies managing the same ecosystems in East Jemez. The findings can also inform how managers are working across management agencies and considering stakeholder groups, including local Pueblos and communities. This research project, along with a similar study in Kenai, Alaska performed by Katherine Clifford and the U.S. Geological Survey (USGS), will allow for a comparative analysis between the two case sites that can bring to light how land managers make decisions during ecological transformation across different landscapes.

III. Background

Climate-driven ecological transformation

Climate change is driving ecological transformation that alters ecosystems drastically and permanently. NPS defines ecological transformation as "a dramatic and irreversible shift in multiple ecological characteristics of an ecological system, the basis of which is a high degree of turnover in ecological communities, and not just change in a single species" (Shimadzu et al. 2015; Schuurman et al. 2020). Ecological transformation can happen suddenly through disturbances like wildfires or floods or gradually through changes to climate like warming temperatures or sea-level rise.

The magnitude and speed of climate change are increasing the frequency of sudden changes in ecosystems around the world (Turner et al., 2020). For example, the conversion of coniferous forests to shrubland and chaparral is prevalent from Mexico to Alaska (Jackson, 2021). Results from a study published in *Science* indicate that terrestrial ecosystems around the world are threatened by major ecological transformations which can disrupt biodiversity and ecosystem services (Nolan et al., 2018). The transformation of Acadia National Park from Boreal spruce-fir forest to invasive shrubland is one example of an ecosystem that has undergone ecological transformation. The wildfire-driven change from coniferous forest to shrub fields in the East Jemez area in New Mexico is another relevant example, examined in this study.

Implications for public land management

Climate-driven ecological transformation has significant implications for public land management and conservation. Climate change poses a challenge for public land managers because traditional ways of managing resources, which aim to preserve and restore land to a past "natural" state, can be less effective during climate-driven ecological transformation. Land managers in federal agencies including the USFS, the NPS, the U.S. Fish and Wildlife Service (USFW), and the USGS must determine new ways to approach land management during ecological change.

A growing body of research and technical assistance is emerging to address ecological transformation (e.g., Biggs et al. 2018, Carpenter and Brock 2006, Turner et al. 2020), but there has been insufficient focus on factors that shape managers' decisions when faced with ecosystem transformation. Social, cultural, and institutional factors play an important role in management decisions and conservation outcomes. According to a recent paper by Clifford et al., "internal factors (mental models) and external factors (social feasibility,

institutional context, and scientific uncertainty)" shape management decisions. Guided by these factors, land managers may think different strategies are optimal for an ecosystem.

Resist, Adapt, Direct Framework

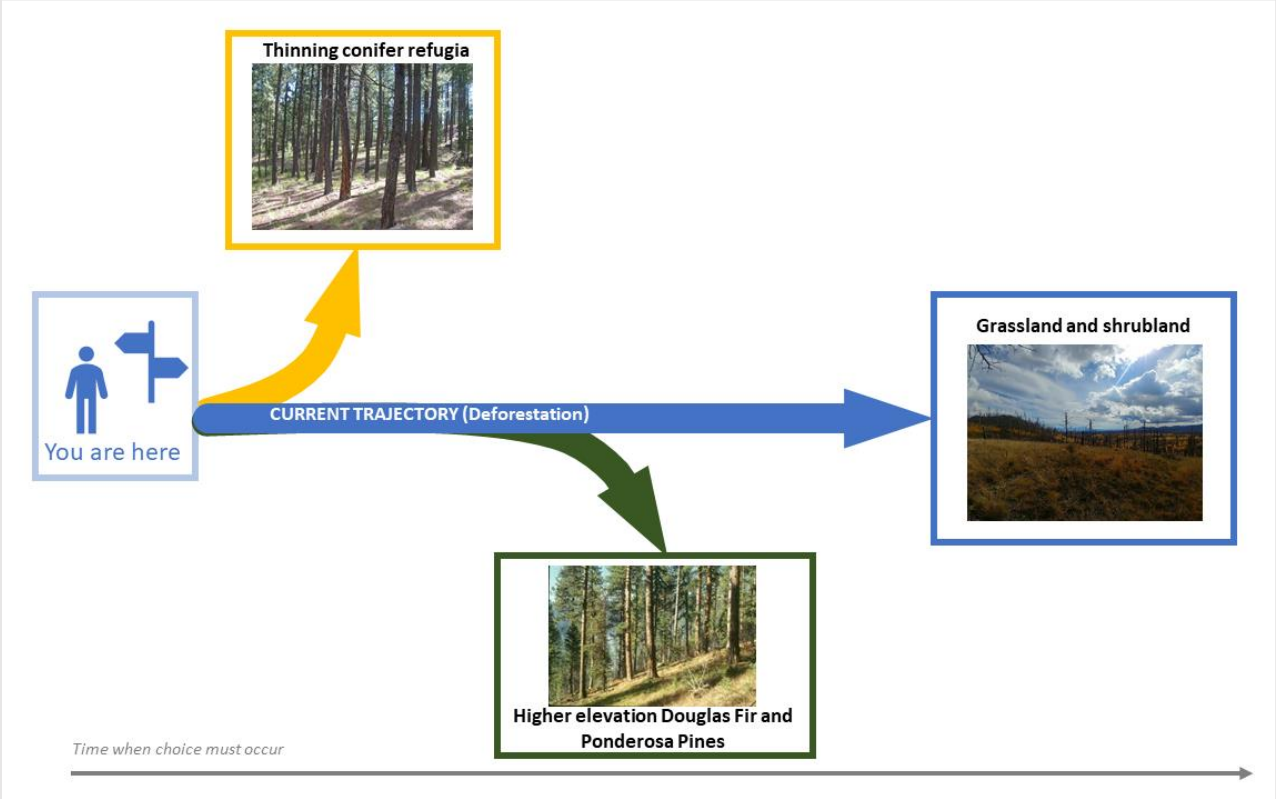
The NPS and its partners developed the RAD (resist, accept, direct) climate adaptation framework to help land managers with climate-responsive planning and management practices. The resist option allows for managers to resist certain climate impacts and maintain natural and cultural resources within what land managers have historically defined as the "desired conditions." In East Jemez, resisting change would look like replanting coniferous forest after a wildfire to restore the ecosystem to its previous state.

The accept option allows managers to accept ecosystem changes and alter their strategies to work within a changing environment. In East Jemez, accepting change could mean allowing the landscape composition to change to grassland and shrubland with the understanding that this would result in a different fire regime and require a shift in land management strategies.

The direct option allows park managers to guide "change toward a specific new state because it is feasible to steward change toward a more desirable outcome than what would be achieved with acceptance" (NPS, 2021). An example of directing change in East Jemez might be moving Ponderosa and Douglas Fir to higher elevations and wetter microsites that have a more suitable and fire-resistant future climate.

The body of research on the RAD framework is growing and more land managers across agencies are beginning to utilize this framework for management decision-making. The National Park Service Climate Change Response Program (CCRP) published a paper called "Planning for a Changing Climate" to help parks consider the RAD framework in land management. All three options are considered viable ways to manage public land during ecological transformation, but the choices that land managers make have important implications for ecosystems and the people that rely on the land.

Figure 2: Overview of RAD land management option in East Jemez



East Jemez as a case study

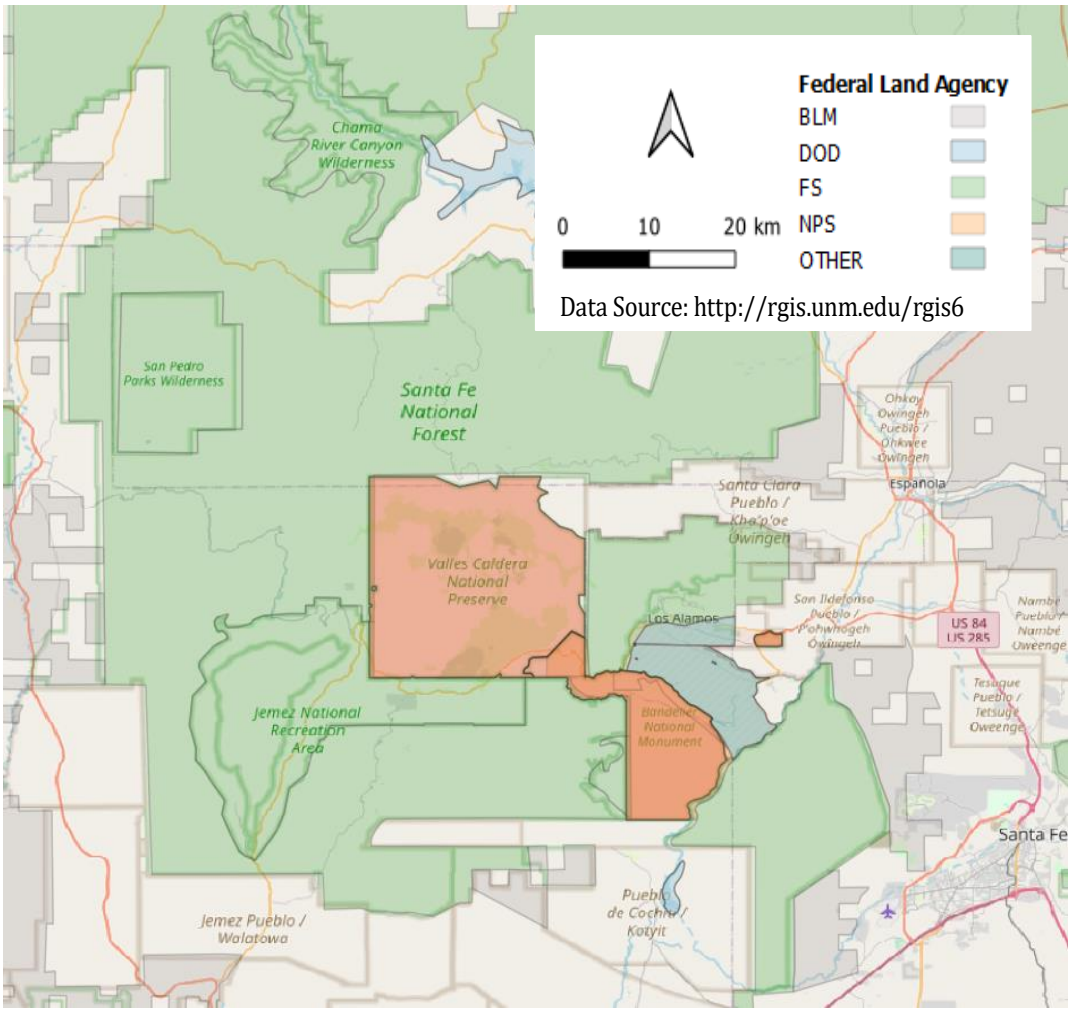
The Jemez Mountains in New Mexico are characterized by a dry climate with frequent droughts. Frequent, low-burning fire has been a natural part of the Jemez ecosystems (Allen, 1989; Touchan et al. 1996). Jemez also has a history of grazing that diminished native grasses and led to the transition to dense stands of fire-sensitive pinion juniper. With climate change, the pinion juniper is further out-competing native grasses.

Fire exclusion, the act of attempting to eliminate fire from a landscape by leveraging fire suppression techniques (USDA 2002), filled in the understory that would have historically burned by natural low-burning fires in the 20th century. In the mid-1990s, the area also experienced prolonged drought and hotter weather due to climate change. These factors have contributed to high severity fires across the eastern Jemez Mountains. Key fire events in East Jemez that have shaped the landscape and local land management needs include the Dome Fire in 1996, the Cerro Grande Fire in 2000, and the Las Conchas Fire in 2011 (Stortz, Haffey, and Kimball 2017).

Severe fires were followed by monsoons and flooding, which have resulted in significant erosion. In response, managers have tried to resist change by reestablishing native grass to slow soil loss. However, efforts are slowing ecological transformation processes rather than counteracting or reversing them.

Land in East Jemez is managed by Los Alamos County, private landowners, several Pueblos, the USFS, the NPS, and the BLM (Lehnert, Haffey, and Stortz, forthcoming). East Jemez is the ancestral land of the Santa Clara and San Ildefonso Pueblos in the north and the Santa Ana, Jemez, San Felipe, and Cochiti Pueblos in the southern part of the range (Lehnert, Haffey, and Stortz, forthcoming). The two agencies included in this study, the USFS and NPS, manage the Santa Fe National Forest, which spans 1.6 million acres and four wilderness areas, and Bandelier National Monument and Valles Caldera National Preserve, respectively (see Figure 1).

Figure 1: Federal Land Agency jurisdiction in the East Jemez region in New Mexico.



The East Jemez Landscape Futures (EJLF) project is a collaborative that aims to collect input from the community, Pueblos, NGOs, and land management agencies, "to help guide future planning and research efforts in the severely altered landscapes of the eastern Jemez Mountains" (Bassett, 2018). EJLF is a key initiative in the East Jemez region and published a report in 2017 titled *East Jemez Landscape Futures Needs Assessment and Recommendations: Identifying cross-boundary opportunities for management in altered landscapes* identifying gaps in current research regarding ecological transformation in the region which was integral to this study.

IV. Methods

To understand which factors influence land manager decision-making and how they vary across USFS and NPS, I conducted and qualitatively analyzed interviews with land managers. This study was approved by Duke University's Institutional Review Board (2022-0205).

Data collection through 19 semi-structured interviews (SSIs) with federal and state land managers was conducted from December 2021 through January 2022. SSIs allowed the flexibility to follow up with probing questions and have in-depth, rich conversations with land managers (Kakilla 2021). SSIs also ensure that complete and consistent information that lends itself to analysis and identification of common emergent themes is gathered from participants (RAND 2009). I interviewed nine land managers from the USFS, eight from NPS, and two from the State of New Mexico Forestry Division with an 86% overall response rate.

Figure 3: Overview of interview participants

Affiliation	Interview Count	Fields
National Park Service	8	Natural and cultural resource management, science and stewardship, biology, archaeology, fire ecology, fire management.
U.S. Forest Service	9	Silviculture, forest fuels, fire management, soils and watershed, natural resource management, GIS.
State of New Mexico	2	Tribal relations, forest and watershed health.

Participant Selection

Participants were identified through purposive sampling with the assistance of Collin Haffey, the Forest and Watershed Health Coordinator for the New Mexico Forestry Division. Purposive sampling is non-random and ensures that the sample of managers has expertise in a variety of disciplines (i.e. silviculture, fire management, etc.) rather than a random sample that might miss important perspectives. The sample included participants from different levels of seniority, subject expertise, and job titles. The sample was supplemented through snowball sampling, with the objective of interviewing a minimum of eight participants from both the USFS and NPS. Snowball sampling leveraged the help of the interviewees to help recruit additional participants (Robinson 2014).

Sample

Participants held a variety of roles at NPS, USFS, or State of New Mexico Forestry Division and their tenure ranged from having started in their role in the last two years to several decades of experience with the agency. The sample included line officers and supervisors

working in a range of fields, including hydrology, forestry, fires management, biology, archaeology, silviculture, and tribal relations.

Interviews

The interview guide was drafted with the help of Collin Haffey and Katherine Clifford. I finalized, adapted, and piloted the interview guide (Appendix A). I conducted interviews primarily over Microsoft Teams video calls, with one interview conducted in the field in East Jemez. Interviews took 45-75 minutes, on average, and all but two were recorded with the consent of the participants. I used a visual to guide the conversation (Appendix B).

East Jemez site visit

To understand the landscape and ecosystems in East Jemez, I visited the region in early December. I conducted one in-person interview with a land manager and learned about the area through a site visit to a USFS reforestation project and the area affected by the Las Conchas Fire.

Analysis

Transcripts, memos, and field notes were entered in NVIVO-12, and I performed analysis to identify emergent themes, using an abductive coding approach. USGS funded transcription services through Landmark Associates. I coded the interviews line-by-line and then abstract up to develop key themes (Feldman, 1995).

V. Findings and Recommendations

Key findings fall into four categories: 1) general perceptions of the RAD framework, 2) internal factors that influence decision-making, 3) external factors that influence decision-making, and 4) barriers to responding to ecological transformation. The first three categories of findings describe how natural resource managers make land management decisions during ecological transformation, what factors influence them, and how these may differ between NPS and USFS managers. The final category of findings examines the barriers that might prevent land managers from successfully responding to ecological transformation and presents recommendations for addressing these obstacles.

General perception of the RAD Framework

1. **Most land managers are open to all three land management options (resist, adapt, and direct) and think they should be strategically combined.** Land managers stated that thinking about the landscape and determining which areas are most suitable for each management strategy based on the criteria outlined in the next sections, is the best land management approach for the East Jemez region. Land managers shared:

> I would select a combination. The way I see it, even though we're very early in the process, I see we're moving in that direction… Then we have to

determine where we believe we can have the best chance of—through management, planting and other types of management, burning, you name it, fire suppression, building up these refugia areas both on the mesa tops, on the north slopes, down in the canyons, riparian areas. I really see it as a combination.

– USFS land manager

I would protect the refugia, encourage the ongoing production of a seed source and regeneration, see what happens. The vast areas of shrubs and grasses, I think, should just be kind of left alone and monitored so we can learn from this new-to-this-area ecosystem transformation. Yeah. It's like a combination. I'm a very practical person, and to me it seems like protecting refugia seems doable. Trying to restore, like, huge acreages of shrubs and grasslands to some forest ideal is just not practical at all. I think it is worth it to try to protect and encourage the little pockets we have left.

–NPS land manager

2. **Resisting ecological transformation is the most widely accepted land management option for USFS and NPS land managers.** All land managers expressed support for resisting the fire-driven loss of conifer refugia via thinning, reducing surface fuels, and conducting regular controlled burns in the pockets of forest that have not yet converted.

I think [resisting] is expected by a lot of our stakeholders. I think this has become very normalized in the Forest Service's work. We've been doing this for a long time—thinning and burning to try to minimize disease and improve the health of trees. For a lot of people, this is expected.

–USFS land manager

I know we will continue thinning refugia like I said. It's just so ingrained in who we are as an agency and what we do. We're just not gonna give up. We're gonna fight as hard as we can to save what we've got.

–USFS land manager

3. **Most NPS and USFS land managers view accepting the transition to shrubland and grassland in some areas as inevitable.** The inevitability of the transition in some parts of East Jemez is seen as a benefit by some because it frees up resources to invest in other management options in more suitable areas.

[Accepting] is the realistic option for the vast majority of places. This is what's going to happen whether we want it to or not. We just have to accept that. We should not be putting tons of resources towards this because it's just going to happen.

–NPS land manager

> The benefit [of accepting the transition] is, that's what's happening already, and it's what the natural environment is doing at the moment, so anything that we do outside of this is going to be a lot of work, and not just now, but ongoing. That's one of the things we always have to remember is that any management that we start is not a one and done.
>
> *–NPS land manager*

4. **A small minority of USFS land managers had an aversion to or a conservative approach towards accepting the conversion of forests to grassland or shrublands.** One land manager characterized accepting the conversion as "benign neglect." Others acknowledged that the conversion to grasslands or shrublands will happen because the "land is [going to] dictate" that, but it is still a land management option that should be limited.

> I think there's been a lot less focus on either accepting conversion of grassland or shrubland, and that's both, I think, inherently kind of human that neither the public nor, I think, the agencies that are managing forests want to accept that as a reality, even though there's some level of acceptance that has to occur in terms of our capacity to deal with it.
>
> *–USFS land manager*

> I think the conversion to grassland/shrublands isn't really—I don't see it as being an option. I think the land is gonna dictate that, so I wouldn't put a percentage on—say 20 percent we just give up on. I'd look at the landscape and go, "We can't do anything here. It's too far gone." The moving the pine and the Doug fir up the mountain, like I said, I'm probably a little more conservative in thinking about that. I definitely wouldn't discount that. Maybe 10 percent of my planting area, I would look for options to do that.
>
> *–USFS land manager*

5. **Some land managers show resistance towards the "direct" option.** USFS land managers showed more hesitation towards "directing" ecological transformation than NPS land managers. Land managers reported that "there's a lot of unknowns" with the "direct" strategy and that it is a "really technically difficult thing to achieve." USFS agency staff are especially "hesitant to be talking about" directing ecological transformation.

> I would say there's a bit of resistance internally to start doing stuff like that. I don't think there's anything to say that we couldn't do that, but I will say from at least the staff on this forest, the silviculturist, and others, were quite hesitant to be talking about that.

–USFS land manager

There's a lot of unknowns…I'm betting more on natural adaptation than I am on human re-engineering of species.

–USFS land manager

I think it would be difficult to actually be successful doing that in the short-term. I think that that option kind of is hard because it requires kind of a longer time span than I think we're willing to give it, in terms of evaluating it. It just seems like a really technically difficult thing to achieve, and then risk because we don't really – I mean, it's kind of an educated guess as far as, yeah, to me, that seems like more of an ecosystem function that we should almost let leave be, you know? To me it doesn't seem worth the technical input that it would require from federal land managers.

–NPS land manager

Internal factors that influence decision making

Land managers reported that internal factors based on their own values and understanding of land management influence their decision-making under the RAD framework. Internal factors including personal valuation of forests, moral imperative, and land management practices ingrained from past formal training, influence land manager decisions in ecological transformation.

1. **Land managers expressed that forests are valuable to them on a personal level.** They reported that maintaining forests is important for "recreation and personal solace" and that "people like to see trees."

   Then on top of that, of course, the value of wildlands that you're maintaining these forested ecosystems for recreation and personal solace and—it's been long understood that people living in cities appreciate forests even though they never go there. They don't have to actually physically visit it as long as they know it's there and they can see pictures and TV and documentaries of things going on in the forest. They're very willing to provide funding through taxes to the Forest Service and the Park Service and Fish and Wildlife Service, things like that even though they may never actually go there themselves.

   –NPS land manager

   Well, within the organization, like I just said, on any given day you may feel like you're taking too many trees. I think that's kind of a subconscious decision that they just—like I said, people like to see trees. You start throwin' a lot of paint on to cut, there's some psychological thing that you just don't wanna cut a lot of trees. I think over the past few years, since we're starting to understand more and more about restoration forestry and how the forest really should look, people are understanding that they need to be way more

> open. The public definitely hasn't swallowed that pill. They're very sensitive to us reducing a stand that's 120 basal areas down to 40. They just don't understand what it should look like.
>
> *–USFS land manager*

However, there are also land managers, who have an aversion to letting these values dictate land management decisions. One fire management specialist shared:

> I have a bigger perspective and I've been involved with fire for so long that it rubs me the wrong way when I hear people generally saying, "We've got to save the planet." It's like, "No, no, [laughter] the planet will be here, [laughter] and life will persist in some way." It may not be the way it looks now or with the diversity that we have, yeah, so maybe it's a good thing I'm not the manager making the decisions 'cause I do have more of a hands-off approach.
>
> *–NPS land manager*

2. **Land managers expressed that they have a moral imperative to manage and restore the land for cultural uses.** Several land managers mentioned that they are aware that certain tree species, like Douglas fir, are integral to Pueblo traditions. One land manager shared that, although it may not be explicit agency policy, there is a "moral imperative" to consider cultural uses when making decisions under ecological transformation.

> We do know that there are some species like Doug fir that are really important. If Doug fir is extricated from the entire Jemez Mountain range, then where are the Pueblos going to go for fir boughs that they need for ceremonies and traditional uses? We really tried to focus a lot on that idea too. When you talk about which option to use and the cost-benefit, I think we have to think about what can we do. Again, it's not necessarily in our policy, but, to me, it's a moral imperative. We are managing lands. Whether those groups want us to manage the land or not, we have been directed by Congress to manage these lands for both the benefit of, both the American people but also for tribes that have a special relationship to that land. How do we make sure those species that they need to continue their traditional practices exist on that landscape? Can we do that? Can we create a future where there is Doug fir, where the kinds of plants they need still exist in the places they've gathered them for hundreds or thousands of years?
>
> *–NPS land manager*

3. **Land management practices ingrained from formal training were also a factor that guided land manager perception of the RAD framework.** One land manager shared:

> That's what I've always been taught through school and grad school and all my trainings, how to preserve and restore habitat for your species that you have. I guess that would be the way I'm thinking.
>
> *–NPS land manager*

External factors influence land manager decision-making

1. **Agency norms and guidance influence land manager decisions.** USFS land managers often cited the New Mexico Forest Action Plan as critical agency guidance to adhere to when making any land management decisions, including during ecological transformation. When asked about accepting ecological transformation, one USFS land manager shared, "it's an option that is not really in our forest plans. It's not one of our desired conditions."

> Yeah, desired conditions formerly really come from our forest plans. Our forest plans come from, obviously, years of engagement with our partners and with the public. Desired conditions ultimately do come from internal agency or our knowledge base research. Also, as we're going through this forest plan revision, we do take into account with partners and with the public what those comments give us that help shape our desired conditions for a given resource. Once they're printed in the book, they maybe appear that they're Forest Service centric desired conditions, but the process to get us to those should've been an integral process, at least in the Santa Fe, of eight years of working with the public and working with our partners and trying to get desired conditions for a multiple-use agency. That's pretty big.
>
> *–USFS land manager*

> Our forest plans say that every acre that is ponderosa pine and dry mixed-conifer will be restored. We don't have an alternative strategy in the areas that we can treat. Now we have wilderness. We have steep areas. We have areas that are not feasible, but all of the feasible acres, that's our objective.
>
> *–USFS land manager*

NPS land managers had more varied perceptions of how the National Park Service's policies guide land management. One land manager shared, "as a park service, I feel we can pretty much do whatever we want with our land and protect it like that if we wanted to." When asked about accepting ecological transformation several land managers shared that it is not an option they think about or that it "is not the approach that park service managers tend to take." Despite diverse responses, agency norms and expectations were frequently discussed as a key factor that influences decision-making.

2. **Public safety is a key consideration when selecting which RAD option to pursue.** Land managers expressed that the protection of people, communities, and infrastructure take precedent when making land management decision-making in wildfire prone areas like East Jemez.

> You try as best you can in these environments of suppression, to try and lessen the impact. What we're doing now, is like trying not to kill people too. Trying to back off to get the roads and like, you're going to see some bad stuff happen when you back far away and let fire do what it wants.
>
> *–USFS land manager*

> One [factor] is what you're protecting. Usually, people and infrastructure rise to the top, so areas around communities, around infrastructure, those are usually the first things that get done.
>
> *–NPS land manager*

3. **Ecological factors including protecting threatened and endangered species habitat, maintaining ecosystem services, and supporting biodiversity influence land manager decision-making.** Both NPS and USFS land managers indicated that selecting management strategies that protect areas with high biodiversity or threatened species habitat is a priority.

> Without the diversity across the landscape, thinking at scale from the fine, the mid-scale to the large scale, that diversity is key. We should have some of these systems everywhere across the landscape. That is maybe more of what's sustainable.
>
> *–USFS land manager*

> [Threatened and endangered] species habitat, stuff like that. If we're gonna burn down the last spotted owl, we would go in and try and protect that. That could be more of a priority. Depends on the area. Yeah. It really depends on, I think, what your objective is and what it is you're trying to protect. If the answer ends up being, it's just the trees and the forest, it's probably gonna fall lower than the ones that are protecting also people or the endangered species or something like that.
>
> *–NPS land manager*

4. **Logistical factors including feasibility, capacity, and effectiveness influence land manager decision-making.** Some land managers emphasized that the accessibility of a site determines the feasibility of a hands-on land management option like resist or direct for that location, especially since managing a burn area is an ongoing process rather than "one and done."

> There's not a lot of roads. I carry hundreds of seedlings in on my back to places just to be like, "I'm gonna put a tree here." 'Cause I was going out there anyways, why not plant a hundred trees or something. Logistically, you can't get hundreds of thousands of trees planted in a canyon…at least not using traditional methods. I really wanted to start exploring seed balls and dropping them and coming up with a better way of doing that. I think there's a lot of potential there that we need to be exploring because this is happening everywhere on huge scales, like million-acre fires.
>
> *–NPS land manager*

> Do we have reasonable access that we can not only try to establish something, but can we continue to do ongoing management? Because, like I said, it's not a one and done. That's gonna be a challenge down in some of these deep canyons. I was never here before those canyons burned, but I heard they were spectacular.
>
> *–USFS land manager*

Land managers also emphasized that capacity, including funding and human capital, are factors that guide land management decisions. Even when there is enough funding, agencies are often understaffed and do not always have enough personnel to "spend it right."

> It was often a matter of money and people. If you had more money and people, you could do more good things in the world. You only have a finite amount of people and money
>
> *–NPS land manager*

> I think that's gonna happen when the money starts flowing in from Biden's infrastructure bill. That we're gonna be overwhelmed with money and we're not gonna have the personnel to spend it right.
>
> *–USFS land manager*

5. **Maintaining and conserving forests for recreation influence manager decision-making.** USFS land managers more frequently mentioned supporting recreation as a key factor for land management decision-making.

> We have recreation benefits. We're a multi-use agency, and we implement under the Multi-Use Sustained-Yield Act of 1960, I think it was. I mean, that is our order, is multi-use management. We can't lose the forest for the Forest Service.

–USFS land manager

Barriers to responding to ecological transformation

1. **Scientific uncertainty poses a decision-making challenge when considering the "direct" land management option.** "Convincing people that the models are correct," poses a challenge for selecting the "direct" option while the science behind resisting ecological transformation is more widely accepted.

> [Regarding directing]
> The biggest challenge is—and just convincing people that the models are correct too. Our science points towards this being the trajectory and that we shouldn't just try to put things back how they were at some preconceived time, right? Like, "Okay, we're gonna go for 1993, and we're gonna make the landscape look like that." … That's what a lot of people wanna do, right, especially in park services
>
> *–NPS land manager*

> [Regarding resisting]
> I think the science, I feel like, really supports this in terms of folks we've been—the key preponderance of evidence, at least for most of the researchers that we're working for, and the public, for the most part, is very supportive of this.
>
> *–USFS land manager*

Recommendation: Establish and communicate agency guidelines, priorities, and desired conditions regarding land management in the face of climate change and ecological transformation. This could involve creating a task force of agency scientists and communications professionals that evaluate and communicate the science behind land management strategies in the face of ecological transformation.

After agency guidelines are clearly established, have frequent discussions with line officers regarding acceptable land management practices under ecological transformation and create opportunities for land managers to share their experiences with utilizing the RAD framework. One USFS land manager recommended:

> I think making sure the science is solid and coming in and having this discussion, I think there is some internal steps 'cause there would be some hesitancy from some of the specialists who are trained in this and how they've done things for a long time. There's always some skepticism and hesitancy to do these changes, but I don't think it's insurmountable, but it would definitely take some effort and a concerted effort of making sure that science is there and getting folks to embrace it.

2. **Slow agency responsiveness can be a barrier to making effective land management decisions in the face of ecological transformation.** An NPS land manager reported:

> I think ecologists, biologists, land managers, in general—I've got this phrase that I came up with called "Documenting Decline." We're really excellent at doing that. We're great at producing literature that shows our forests are fallin' apart, or we're not getting seedling regeneration, or there's all this erosion. We're really bad about taking that information and putting it into action on the landscape. That's because there's all sorts of challenges with doing that. It's hard, and there's not a lot of projects out there. You don't feel like you have support to do it.
>
> *–NPS land manager*

Recommendation: Support more collaboration and network-building between scientists, land managers, NGOs, community members, and local tribes through groups like EJLF. Partner groups like EJLF can be more responsive and more rapidly collect stakeholder feedback, identify research and community needs, and inform land management. Agencies can leverage insights from partner groups to support land managers more effectively in responding to ecological transformation.

3. **Personnel turnover is high and poses a barrier to building lasting relationship and networks with other agencies, tribes, and the local community.** These are all important stakeholders when considering land management in the face of ecological transformation, however having to build new relationships every few years stalls communication and impacts trust.

> Then the third thing I think is just in the federal system at least, there's so much turnover. This continues to come up in every single conversation, but if we're not gonna change that, how are we gonna supplement the—how are we going to compensate for that, where the federal folks are turning over all the time and it makes it really hard because by the time you—just when you start to get that relationship feelin' good and comin' along, that person takes off. It sets you back and just from a morale standpoint on the partnership, every—you just can't keep doin' the same thing and building the same—building relationships with people. You need some people to be willing to stick around or shift some responsibility so that they don't—you don't have to build those relationships to such a degree every single time someone changes jobs.
>
> *–State of New Mexico land manager*

Recommendation: Develop protocols to ensure key relationship with tribes, the local community, and agency partners are not affected when there is staff turnover. This could include creating a task force so that there is continuity in relationship-building. Build collaboration partners into the roles of land managers to ensure that it is prioritized.

IX. Conclusion

Through interviews with USFS and NPS land managers in East Jemez, this project empirically examined land manager decision-making processes in the face of wildfire-driven ecological transformation in East Jemez to explore two questions: how do natural resource managers make land management decisions and determine future desired conditions during ecological transformation? How does this process vary between different land management agencies?

Key findings fall into four categories: 1) general perceptions of the RAD framework, 2) internal factors that influence decision-making, 3) external factors that influence decision-making, and 4) barriers to responding to ecological transformation. Most land managers interviewed supported a strategic combination of resisting, accepting, and directing ecological transformation. Internal factors that influence decision-making include personal valuation of forests, moral imperative, and land management practices ingrained from past formal training. External factors that influence decision-making include agency norms and guidelines, maintaining public safety, protecting ecological diversity and threatened and endangered species habitat, enabling recreation, and general feasibility. Barriers to land management under ecological transformation included slow agency responsiveness, a sense of scientific uncertainty, and agency personnel turnover.

This study contributes to the body of research by empirically examining theoretical frameworks developed to conceptualize land manager decision-making processes under ecological transformation, like the framework developed by Clifford et al. in 2021. Additionally, this research follows the EJLF Needs Assessment published in 2017 which calls for additional research to support an interdisciplinary and collaborative approach to managing the ecological transformation that the landscape in East Jemez is experiencing.

A key limitation of this study is that it does not include the first-hand perspectives of East Jemez Pueblos. Without the contributions of local tribes, the effectiveness of any land management strategy in the face of ecological transformation is limited and incomplete. This work provides the preliminary findings that help develop the foundation for future research that meaningfully engages with local communities and Pueblos to encourage co-management and collaboration in land management decisions. Future projects may use these research findings regarding how managers make climate adaptation decisions to explore how Pueblos can bring their knowledge, preferences, and guidance to inform management efforts.

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Appendices

Appendix A: Sample Interview Guide

I. Opening Questions

Background:

1. Can you tell me a little about what your job entails?
    - Probe: What types of decisions do you have to make?
2. What do you see as the biggest challenges the park/forest faces in the next 10 years?

II. Main Questions

Manager perceptions of ecological transformation:

3. How do you expect forests in the East Jemez (or Northern NM or Southwest broadly) to change in the future?

Managing ecological transformation:

4. How, if at all, has fire-driven changes of forest to shrublands or grasslands affected your job/ability to manage resources?
    - Probe: How much of your work is impacted by this change?
    - Probe: Has ecological transformation changed the types of decisions you are making? If so, how?
    - Probe: Uncertainty: what trigger you to change the way you manage these novel conditions? (OR: How much does the uncertainty of these decisions play into whether you take action or not?)
5. How much do you work managing post-fire environments with [other agency: park/forest service] or other partners like tribes? And in which ways?
    - Probe: are there any barriers that limit this? What would enable it more?
    - Probe: Who funds this collaborative work?

Multiple Trajectories in East Jemez:

Now, I am going to be asking you your opinions about managing ecological transformation and focusing on the transformation in the fire-driven forest to shrubland/grassland conversions in the East Jemez. There is no right answer as to how to respond; each manager has to determine what they think is best for their ecosystem based on a number of different criteria.

For this section, I will use some visuals to guide the questions. Broadly, you have two choices on how to respond to the fire-driven transformation of forests to grasslands or shrublands. You can try to restore forests in these areas, or you can adapt to the

conversion and manage for shrublands or grasslands. I am going to ask you about strategies for both.

Reforest options:

First, I am going to start with strategies to reforest. One option is to resist the fire-driven loss of conifer refugia via thinning, reducing surface fuels, and conducting regular controlled burns in the areas that didn't convert (i.e. remaining pockets, or proactively in areas that didn't burn).

6. What do you think are the benefits and threats of this option?
    - Do you see any constraints that would prevent you from choosing this option?
    - Does this seem like a choice that would be feasible with stakeholders? Do you have any concerns with this choice and your stakeholders?
    - How does this affect your ability to partner across boundaries?

A second option is that you could move native tree species and genotypes upland to place that will have a better suited future climate (e.g. moving Ponderosa and Douglas Fir to higher elevations and wetter micro sites).

7. What do you think are the benefits and threats of this option?
    - Do you see any constraints that would prevent you from choosing this option?
    - Does this seem like a choice that would be feasible with stakeholders? Do you have any concerns with this choice and your stakeholders?
    - How does this affect your ability to partner across boundaries?
8. Would you ever consider reforesting post-fire areas with tree species not currently present in the E Jemez that you anticipate would be better adapted to future climate conditions and fire regimes? Why or why not?*

Accept option:

Next, I am going to ask you about strategies to adapt to the conversion (and the new shurblands and grasslands). You have two main options.

The first option is that you could just allow the grassland and shrubland to change in process and composition with an understanding that these areas may be more suited towards a warmer climate and recognizing they will carry a different fire regime.

9. What do you think are the benefits and threats of this option?
    - Do you see any constraints that would prevent you from choosing this option?
    - Does this seem like a choice that would be feasible with stakeholders? Do you have any concerns with this choice and your stakeholders?
    - How does this affect your ability to partner across boundaries?

All choices:

10. Considering all three options we discussed, which strategy or combination of strategies, do you think would be best? In other words, which would you select and why?
    - Probe: And where would you use them?
    - Probe: for their use of naturalness in responses
    - Probe: for use of stakeholder or partner groups they describe and ask them to describe
11. Are there any options which you consider "off the table" and why?
12. What factors are most important in this decision?
    - Probe: how does spatial scale impact your decision?
    -

Overarching questions about ecological transformation

To finish up this interview I am going to ask you some tough questions. They are hard by design, and it's OK if you need to think over it and if you want to think aloud while making the decision

13. Do you think that managing ecological transformation changes relationships with partners? Or the process of interacting with partners? Or the roles of partners?
    - Who needs to be at the table to help you make decisions?
    - What role does tribal consultation play in a time of ecological transformation?
14. How do these decisions feel similar or different from other management decisions that you have made?
    - Probe: Do you feel as confident about these decisions?
    - Probe: Have the stakes changed from typical management?
    - Probe: Are they more stressful than other decisions?
15. Do you consider metrics to evaluate success as similar to or different from those you have used in the past?
    - Probe: how about metrics to evaluate failure? What would constitute a failure?
    - Probe: what would enable you to better be able to respond to ecological transformation within your park/forest?

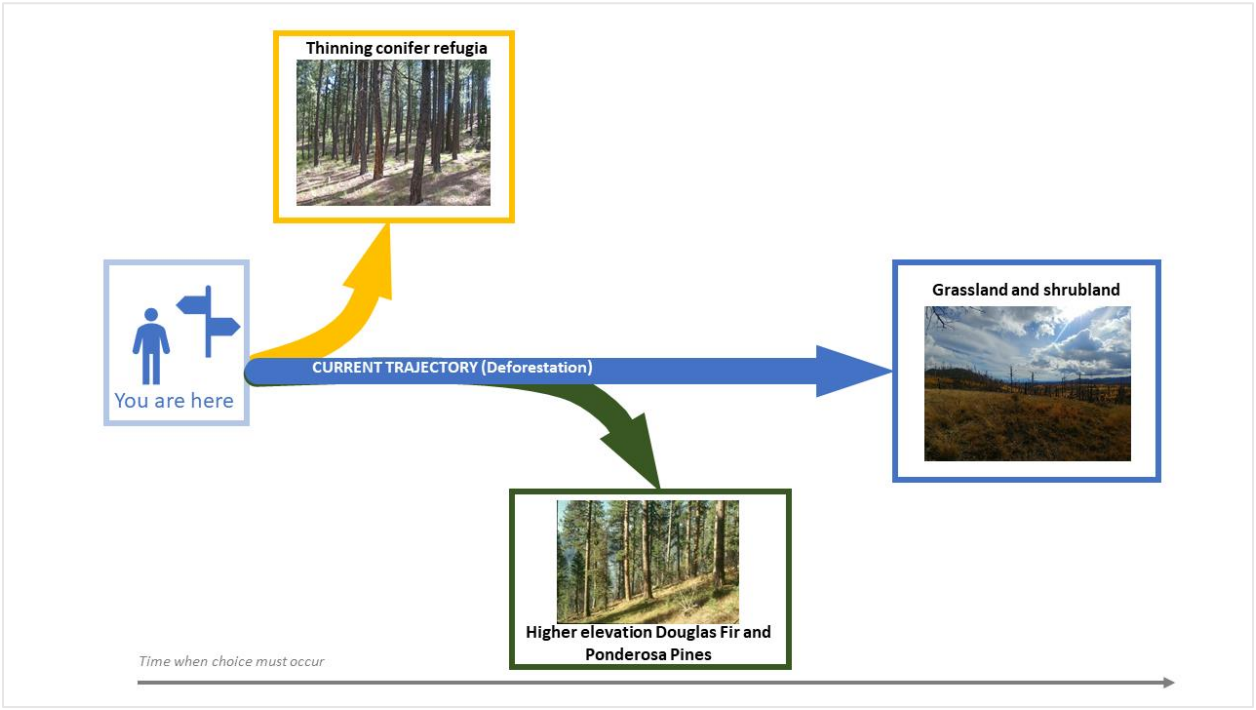
Closing Questions:

16. Is there any topic you would like to expound upon?
17. Do you have any questions for me?
18. Can I reach out if any additional questions come up?

This interview guide was developed by Katherine Clifford, Collin Haffey, and Gaby Antonova.

Appendix B: Interview Visual

Overview Slide:



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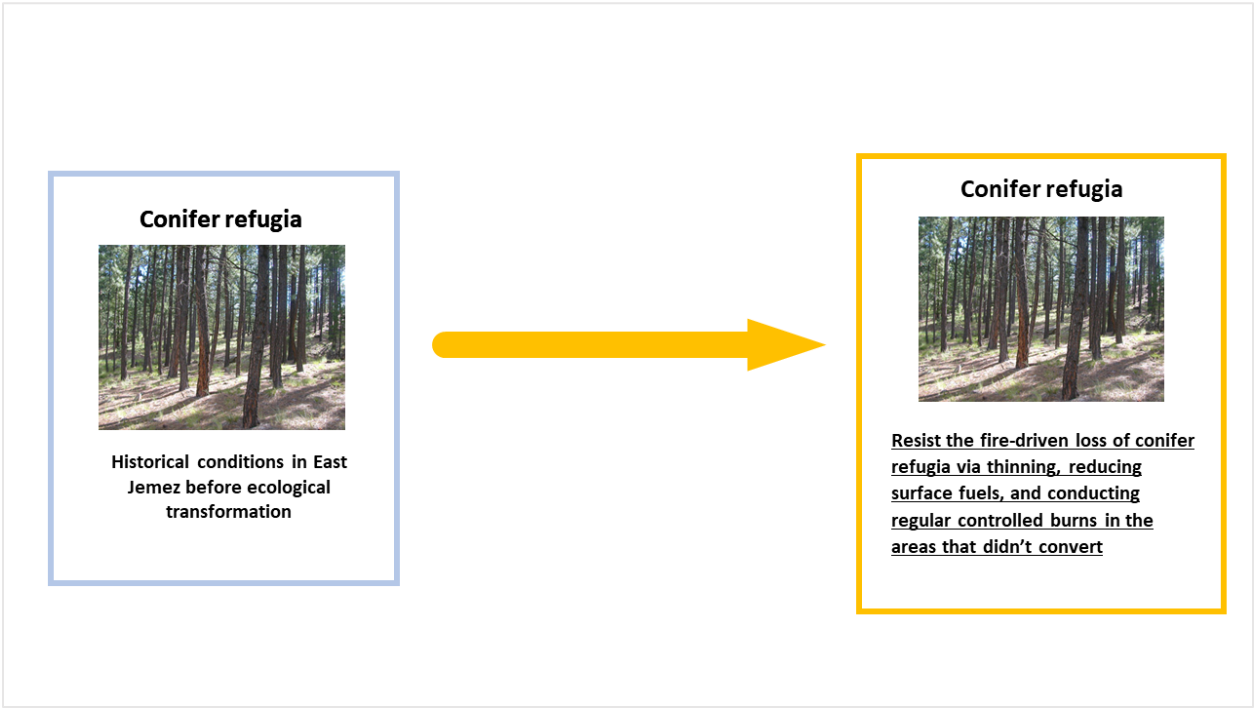

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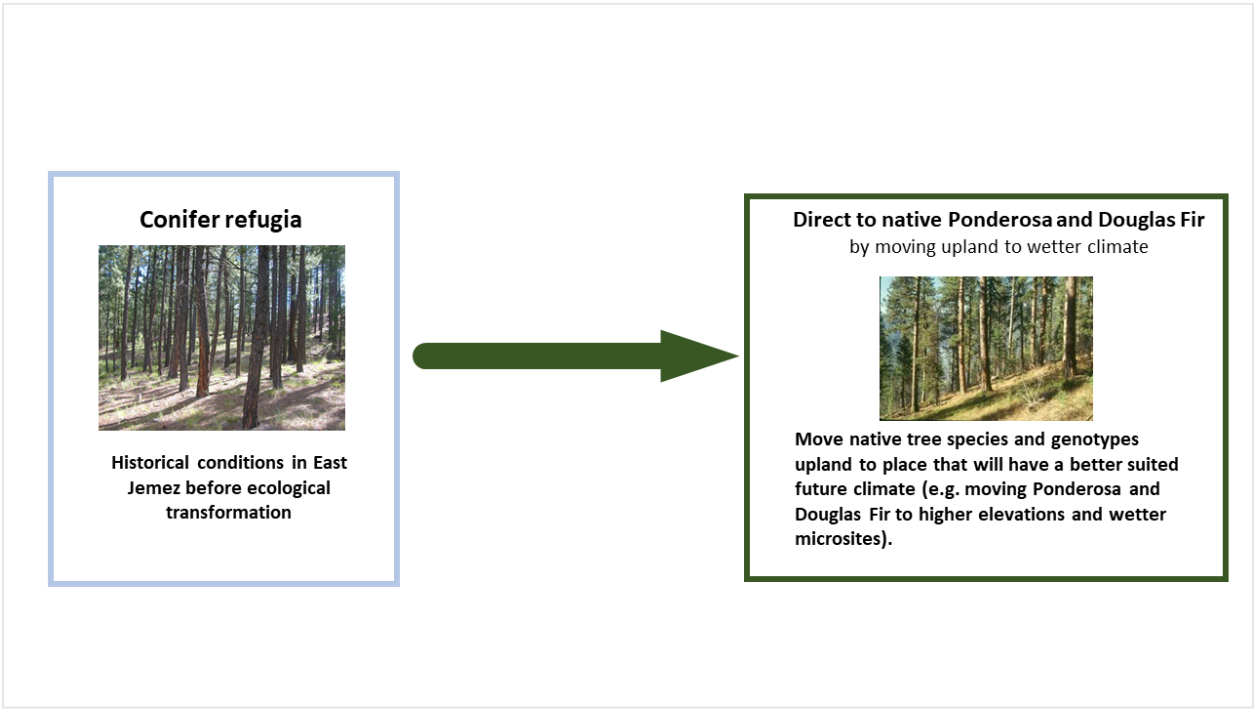
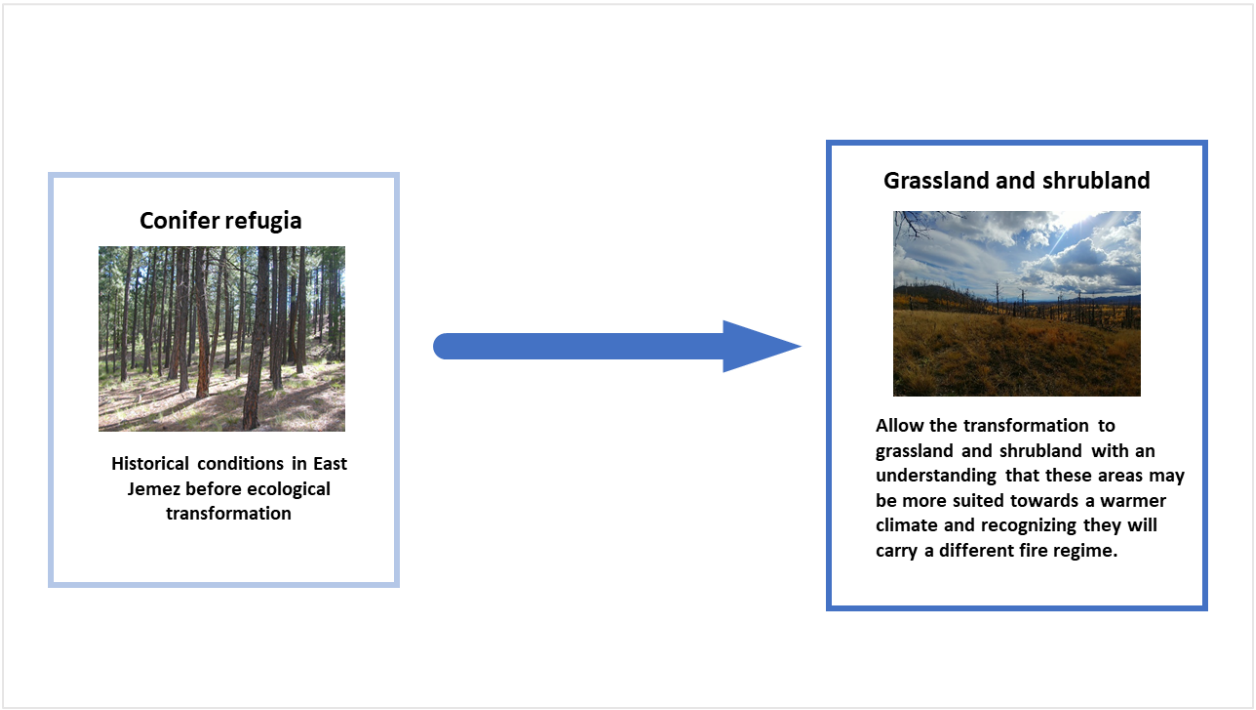
Accept Slide: