Wildfire and Watershed Symposium

October 2 – October 3, 2024

University of New Mexico, Albuquerque, NM

INTERMOUNTAIN WEST
TRANSFORMATION
NETWORK

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Horizon Scan Reviews

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INTERMOUNTAIN WEST TRANSFORMATION NETWORK

Horizon Scan Reviews

PURPOSE

This document synthesizes key topics identified through the **horizon scan** method, forming the basis for advancing research and synthesis papers on post-wildfire restoration needs in the Intermountain Western United States. Contributions from multiple researchers address two critical aspects for each topic:

1. **Potential for Significant Impact**: How addressing this topic could substantially contribute to improving post-fire restoration outcomes.
2. **Urgency and Time-Sensitivity**: Why immediate attention to this topic is essential for guiding post-wildfire restoration and recovery.

The topics have been grouped into three thematic areas:

- **Forestry**: Covering strategies for nursery propagation, planting methods, natural versus artificial regeneration, assisted species migration, and models for reforestation and post-fire vegetation dynamics.
- **Hydrology**: Focusing on erosion, flooding, and debris flow mitigation, fire impacts on snowpack and water resources, watershed recovery, and process-based stream restoration.
- **Social Sciences**: Addressing community resilience, engagement, equity, traditional knowledge, public support for restoration, and economic valuation in recovery efforts; as well as highlighting national coordination, anticipatory governance, pre-fire planning, and workforce development.

At the workshop, participants will engage in discussions where topics will be explored as a thematic block. The purpose of these discussions is to:

- Learn more about the topics.
- Clarify the impact and urgency of each topic.
- Revise wording or combine any overlapping topics.

Though discussions will take place within thematic blocks, it is important to note that in the post-workshop scoring, **all topics will be scored against one another**. This comprehensive scoring will help prioritize the most urgent and impactful areas for guiding future research and practice.

This document will serve as a resource for the in-person discussions, ensuring a productive exchange of ideas and paving the way for the development of synthesis papers that will provide practical guidance for land managers, policymakers, and the scientific community.

FORESTRY

Nursery Propagation: What strategies can be applied in the nurseries that lead to greater seedling survival in the field?

Summarize how addressing this topic would have a significant impact on guiding post-fire restoration and recovery.

Member 1	Member 2
Climate change is having immediate impacts on reforestation efforts by modifying planting environments to conditions that are inhospitable for seedling survival shortly after planting. Thermal anomalies (i.e., extreme heat) and drought are the main driving forces limiting reforestation potential. Currently, most nursery practices grow seedlings under luxury resource conditions which do not match the hot, dry environments likely to be found at most planting sites. A knowledge gap exists on the range of strategies that can be applied in nurseries to condition seedlings, morphologically and physiologically, to extreme environmental conditions through alterations of propagation regimes. Little is known on how the intensity, duration, timing, and types of nursery conditioning treatments (e.g., water stressing) influence morphological and physiological traits across a range of species and genetic sources that ultimately that lead to greater seedling survival in the field.	Planting seedlings offer significant value when there is need for structure and function on the landscape and the present environmental factors are not conducive to natural seedling establishment. This is especially true in post-fire landscapes. Two nursery propagation strategies can help overcome factors that are limiting to seedling survival and growth. The first is the optimization of stock types (seedling species, size, shape, and age) for different planting environments. Many stock types exist, but their true advantages on a range of sites is poorly understood. A second strategy is the alteration of nursery hardening regimes. Recent studies show that limiting irrigation in the nursery may have a drought conditioning effect, thereby preparing them for drier conditions on the out-planting site (without damage to the seedling in the nursery). Further research is needed to fully understand these effects on different species, stock types, phenology, morphology, and physiology. While implementing limiting conditions in the nursery to prepare seedlings for harsh planting conditions, it is still important to maintain high-quality attributes.

Nursery Propagation: What strategies can be applied in the nurseries that lead to greater seedling survival in the field?

Summarize how addressing this topic is time-sensitive and urgent for guiding post-fire restoration and recovery.

Member 1	Member 2
Science-based reforestation has the single greatest potential for climate change mitigation compared to all other land management activities. However, the backlog of reforestation needs (400,000+ hectares/year) across the United States continues to grow each year in direct response to disturbances such as those caused by fire, insects, and disease. This growing backlog has recently generated significant momentum to improve national reforestation efforts as seen by initiatives such as the REPLANT Act and Executive Order No. 14072 (2022). With massive reforestation actions on the horizon, it is critical to implement climate-smart reforestation that address how trees are planted for future climatic conditions.	Increasing size and severity of wildfires is adding to the increased need for tree planting. When it comes to standard reforestation practices, those following typical forest management activities such as harvesting, much is already known about maximizing seedling survival and growth. Still, there are increasingly unique situations where nursery plant material is needed (such as severe and vast wildfire) and yet the standard knowledge regarding the necessary plant material does not apply. The sites for out planting following fire are becoming increasingly challenging and harsh for typical operational nursery stock. If typical reforestation efforts don't work, is it OK to allow a potential landscape conversion to a new vegetation type? Or, do we employ new strategies to reestablish functional forest ecosystems, like those that were previously in place providing clean water, air, habitat, cultural use, and carbon sequestration? Advancing our understanding and knowledge in post-fire revegetation efforts is critical to providing much needed jumpstarts in the ecosystem services we rely on.

Suggested revisions, Member 1: *NONE*

Suggested revisions, Member 2: *Topic Phrasing*

Nursery Propagation: What strategies can be applied in nurseries and subsequent out planting practices that lead to greater seedling establishment and growth in the field?

Planting Methods: What planting strategies best improve tree survival?

Summarize how addressing this topic would have a significant impact on guiding post-fire restoration and recovery.

Member 1	Member 2
Current seedling survival rates in the southwestern US are approximately 25% (which may still be an overestimation based on ongoing research). This low rate of survival is concerning from both an ecological and economical perspective. Ecologically, 75% seedling mortality will likely result in a very different forest structure and function than that of the original planting density (if no other replants are implemented). Economically, 75% seedling mortality equates to a 75% loss in investment from the beginning portion of the reforestation pipeline (seed and nursery efforts). Thus, it is critical to invest in the entire pipeline, including out planting operations, to ensure higher rates of survival that promote ecological and economic stability.	Planting trees is crucial in post-fire recovery where the goal is to return the burn area to forest and natural regeneration isn't sufficient. Given that, maximizing the success of plantings should be a priority. Some research focuses on both landscape and microsite variables and is helping guide management decisions. Other factors that come into play could include access to planting sites, work force availability, and other realities that may limit the ability to plant in sites identified as preferred for planting success. Planting strategies for success on sites that aren't ideal would be useful for managers who are facing real-world constraints. Planting may occur on sites where pines are not regenerating enough to meet management goals. In areas I'm familiar with, Gambel and wavy-leaf oak become the dominant woody plant post-fire. What strategies allow for minimizing competition between pine seedlings and oaks, or how can the presence of oaks prove beneficial to pine seedling success?

Planting Methods: What planting strategies best improve tree survival?

Summarize how addressing this topic is time-sensitive and urgent for guiding post-fire restoration and recovery.

Member 1	Member 2
As of 2024, there continues to be significant momentum to increase the capacity of reforestation efforts in the US, which includes tree planting. However, with the low survival numbers in the SW region, it is critical to examine planting methods that improve seedling survival. Some of the main reasons for high seedling mortality are the result of water and heat stress, herbivory, disease, competing vegetation, or fire. Many of the proposed solutions to these issues are outdated and/or more applicable to other forest regions. Therefore, a science-based approach is required to understand how best to alleviate these seedling stressors and inhibitors. Examples of new research directions include: 1) new types of seedling protection structures to reduce ungulate and rodent herbivory, 2) exploring the use of nurse vegetation as solar cover for establishing seedlings (reducing both water and heat stress, 3) using nucleation planting strategies (and densities) to focus on specific sites and reduce costs, and 4) promote training on seedling storage, handling, transportation, and planting.	It is time-sensitive and urgent for me as a manager, because we are initiating a reforestation effort in the summer of 2026, for a project that will likely continue for many years. This work is on a fire scar that is 7 years post-fire; many more acres in New Mexico will be achieving a degree of stability in the next few years and accelerated planting efforts are likely to be initiated.

Suggested revisions: *NONE*

Predictive models for reforestation: How do we link site-level conditions and remote sensing data to develop models to improve outplanting success?

Summarize how addressing this topic would have a significant impact on guiding post-fire restoration and recovery.

Member 1	Member 2	Member 3
Across the southwestern United States, high-severity wildfire is causing increasingly large areas of tree mortality and removing the seed sources required for the natural regeneration. Planting tree seedlings can accelerate reforestation, but in the semi-arid southwestern US, the survival of planted conifer seedlings is typically low (mean 25%, Ouzts et al., 2015). This is likely due to a combination of the loss of the solar radiation buffering effects of the overstory canopy after high severity wildfire, climate change driven increasing drought frequency and severity, and temperature increases. However, topography and vegetation both alter the prevailing climate to form areas which promote or decrease seedling survival, largely independent of the prevailing climate. Models which can identify areas that promote seedling survival within a landscape could provide a significant boost to the efficacy of reforestation efforts.	Capacity to plan and implement post-fire reforestation work in the Interior West is exceedingly limited. This can translate to suboptimal outcomes – for example, nearly 50% of USFS post-fire planting projects since the mid-1980s were in locations that had nearby, surviving trees, which may help facilitate natural recovery (Rodman et al. In Review). Predictive models translate best available scientific knowledge into tools that can be readily interpreted and used by practitioners to help support management decisions (North et al. 2019, White and Long 2019, Stevens et al. 2021). FVS is the most widely used predictive modeling tool in forest management, but regeneration models within FVS are not present in some regions (e.g., Central Rockies; Keyser and Dixon 2008). PostCRPT (Stewart et al. 2021), SRRT (Rodman et al. 2022), and RegenMapper (Holden et al. 2022) are existing tools that predict locations where natural tree regeneration is most likely within recent fire perimeters, or sites that might be suitable under future climate conditions. Such information may help to optimize allocation of resources and expedite the planning process.	Changes in climate and shifting site potential in combination with increases in wildfire area have elevated issues with tree regeneration and forest loss in the western US. Remote sensing and other ancillary spatial information broadly available offer promise in meeting the challenges of assessing risk to post-fire regeneration, informing prescriptions and prioritizing planting locations, and in the analysis of monitoring data to explain regeneration and seedling survival that, in turn, helps to assess post-fire risk. Research reveals novel tree regeneration patterns in the West in terms of rates and composition (e.g., Bell et al. 2014, Dowbrowski et al. 2015), corroborates hypothesized directional change and the reduction in the footprint of forested lands (Parks et al. 2019), and the effect of fire on post-disturbance composition and local range shifts (Hill and Field 2021). Studies using repeat sampling of long-term vegetation records can help indicate the rate of directional change (e.g., Brusca et al. 2013, Guida et al. 2014). Such information, when coupled with high-resolution vegetation mapping and climate surfaces (past and future), can be used to effectively assess risk at local scales (USDA Forest Service 2023).

Predictive models for reforestation: How do we link site-level conditions and remote sensing data to develop models to improve outplanting success?

Summarize how addressing this topic is time-sensitive and urgent for guiding post-fire restoration and recovery.

Member 1	Member 2	Member 3
Losing large patches of forest cover to wildfire directly impacts the ecosystem's abiotic properties, reducing retention of winter snow cover, decreasing soil moisture, and increasing near-ground temperatures. Given the narrower fundamental niche space of tree seedlings compared to mature trees of the same species and the altered thermal environment that occurs following high-severity fire, large high-severity burn patches have the potential to remain in a non-forest state for the foreseeable future, converting to shrub or grasslands in the absence of management intervention, such as reforestation. Given the rapidly changing climate, there is a window for reforestation that may close when post-wildfire areas have been converted to shrub or grasslands, water and nutrient availability for planted seedlings is reduced, and areas are beyond the climatic envelope that seedlings may endure. The development and operationalization of predictive models for reforestation may enable the efficient use of reforestation resources to have an outsized impact if deployed promptly after wildfire, providing seed sources for natural succession before land-type conversions take place.	Addressing this topic is timely because post-fire tree planting is currently limited across the Interior West (Dumroese et al. 2019), but likely to accelerate over upcoming years (Dobrowski et al. 2024, USDA 2022). Tools to help practitioners access and utilize best available scientific knowledge will help inform factors such as site prioritization, species selection, and climate-smart reforestation practices. These tools may be particularly valuable to newly hired or inexperienced practitioners. Currently, predictive models to support post-fire reforestation are limited in geographic extent/tree species considered (PostCRPT, SRRT), or focus specifically on USFS lands (RegenMapper), limiting the ability to support cross-boundary planning. These models provide useful functionality (e.g., future climate projections, automated burn severity mapping, site accessibility and management restrictions), but have various benefits and drawbacks. A single tool covering all sites and land jurisdictions in the western US would provide immense value to federal, state, local, private, and tribal entities planning post-fire reforestation work.	The amount of lands in need of planting has been steadily increasing over time, against a backdrop of limited resources for forestation. There are an increasing number of resources and tools available to inform reforestation priorities among landscapes and to prescribe planting down to the site level. Stevens et al. (2021) provide a broad framework for planting strategy including a perspective on prioritization, project-level planning, and tactical approaches. This framework can be augmented with climate adaptation strategy and high-quality datasets for greater effect in decision making and the execution of a planting program (USDA Forest Service 2023). While the framework requires spatially explicit data layers on fire severity and other variables, these types of high-resolution spatial data are now commonly available at least within large wildfire areas. Online tools are now available to inform specifics of a planting strategy and resulting prescriptions, including the Southern Rockies Reforestation Tool (SRRT) (Rodman et al. 2022). The SRRT is a web-based tool that relies on remote sensing and other spatial information to consider key parameters such as distance from seed sources and topoclimatic suitability. Remote sensing and other geospatial information can likewise be coupled with seedling survival monitoring to test relationships between survival and environmental conditions, including climate vulnerability forecasts (USDA Forest Service 2023). Remote sensing and environmental census data are already helping to explain planting failure patterns. This information can, in turn, be used to refine risk assessment for post-fire regeneration and to improve prioritization and other strategy for reforestation.

Suggested revisions: *NONE*

Reburn: How do reburns and post-wildfire fuels management influence future fire-vegetation dynamics?

Summarize how addressing this topic would have a significant impact on guiding post-fire restoration and recovery.

Member 1	Member 2	Member 3
There is legitimate concern about re-burns in contemporary fire science and management. However, a historical perspective based on centuries of fire history reminds us that re-burns were the norm, not the exception, in many ecosystems. The most widely used statistic to characterize fire regimes, the fire return interval, is a statistic of re-burning. It is important to separate a reburn per se from other properties, particularly fire severity, and not make the mistake of thinking that all re-burns are adverse. In fact, preventing re-burning is a proven pathway toward type conversion in a fire-adapted system (what is a grassland without reburning? Not a grassland for long). The ideal management regime is to approximate the historic frequency and severity of re-burns; this can be a challenge, but framing management objectives in terms of repeated burning and not one-off events will help us move toward sustainable ecosystems that can adapt to changing climate. When re-burns do occur with uncharacteristically high severity and/or short intervals, ecosystem reorganization will occur, raising new questions about whether such outcomes should be reversed or accepted.	Reburns alter forest trajectories, however high variability in outcomes depending on forest type, fire interval, fire severity sequence, and other biophysical factors means that we still have limited ability to predict forest trajectories in different situations which could help inform management decisions. We also lack information about longer-term trajectories, which species will dominate if the pre-fire conifers don't regenerate, and what the impacts of those transitions will be for ecosystem function. Studies have examined fuel loads following salvage logging (although mostly in the PNW), but more information is needed about strategies to promote tree regeneration survival through a subsequent fire. For example, information on when and how prescribed fire can be used in recently burned (and planted) areas and how effective alternative planting strategies are at increasing resistance and resilience to future fire is needed. There is little research about how to shift systems out of shrub dominated states conducive to repeat high-severity fires. Landscape-scale studies are needed to help inform where and which treatments could promote landscape-scale resilience to future fire.	Many post-fire management actions specifically address the immediate or moderate term post-fire impacts. However, these actions, such as logging, mulching, seeding and planting, often result in adding fuel to a landscape and increasing the potential for near term reburning. Additionally increased prevalence of invasive species and conversion can increase the potential for future wildfires that reinforce a new ecosystem state unlike those seen within that burn scar pre-fire.

Reburn: How do reburns and post-wildfire fuels management influence future fire-vegetation dynamics?

Summarize how addressing this topic is time-sensitive and urgent for guiding post-fire restoration and recovery.

Member 1	Member 2	Member 3
As wildland fire area burned increases, and the proportion of area burning at high severity also increases in many areas, the probability of re-burning with uncharacteristically high severity is rising inevitably. Since this combination of repeated burning and uncharacteristically high severity is predicted to lead most rapidly to abrupt ecosystem change, a better understanding of the ecology of re-burns and feasible management strategies is crucial in fire science and management. The default management response, to restore a burned landscape to its pre-fire condition, may be problematic because of changing climate and altered processes of post-fire succession. The long-term successional trajectory may be largely determined, or at least constrained, in the early years following a severe event. Once those initial conditions have been established, and assembly rules begin to operate, it may be increasingly difficult to restore those landscapes to the pre-fire condition without enormous effort and resources, and even then, may not be entirely feasible unless undertaken soon after the fire event before other species occupy the site.	Increasing area burned and area burned at high severity due to changing climate conditions means that more area is also burning in short interval reburns. Helping managers understand how to prioritize stands and which strategies to use to treat these areas before they burn again is critical to prevent ecosystem transformation. Studies show that repeat fires can erode fire refugia and result in a cumulative increase in the area affected by high severity fire. It is important to understand where and how to reduce the risk of short-interval high-severity fires in landscapes where this phenomenon is causing forest loss before too many seed sources are killed which would make restoration much more difficult in the future. In other cases, demonstrating the benefit of repeated wildfire for forest resilience through reduced fuels and tree density could inform policy and practice surrounding managed wildfire use.	As wildfires increase in size and severity, we are seeing more and more landscapes experiencing reburning of old fire footprints from the past 40 years. Some locations in the western US that have burned as many as 6 times since 1985, and this issue that was historically more prevalent in Idaho, New Mexico, and California, has now spread to all western states. Repeated fires have many potential compounding impacts such increased prevalence of regeneration failure (Stevens-Rumann and Morgan 2016; Turner et al. 2019), larger more continuous high severity areas (Harvey et al. 2016), and poor understanding of hydrologic processes and impacts to soil.

Suggested revisions: *NONE*

Natural vs Artificial Regeneration: When to select between natural regeneration and artificial (i.e., tree planting)?

Summarize how addressing this topic would have a significant impact on guiding post-fire restoration and recovery.

Member 1	Member 2
This question is most relevant to large (>100ha) treeless landscapes resulting from wildfires. “Large treeless patches have become an increasingly prevalent component of the southwestern postfire landscape (J.T Stevens et al, 2021)” In smaller treeless areas, or areas where normal successional processes are taking place to species like aspen, oak, and locust (albeit on a “normal” scale) this question may be less relevant. The success of reforestation efforts in large treeless environments is still being studied. Independent of the environmental factors that might determine the failure or success of reforestation efforts, there are more subjective and economic considerations that could factor into how and whether to pursue reforestation efforts in large treeless (conifer) post-fire environments.	Based on simple review of the literature, it is evident that there is limited scientific research that provides clear guidance for decision-making relating to natural forest recovery versus tree planting in the Western USA. Few studies explicitly examine natural forest recovery vs. tree planting in the Southwest or in the western USA. Further, few studies provide guidance on decision making for post-fire tree planting given uncertainty of natural forest recovery, while nearly all other studies come from different forest types or other regions globally. Land managers would greatly benefit from science-based decision-making frameworks focused on specific forest types and/or for specific regions. Few studies have focused on decision making support for more mesic/higher elevation forest types following wildfire, given more fires in these forest types in recent years. Finally, a deeper focus on changes in temperature and drought during natural forest recovery or reforestation is critical to best understanding establishing (naturally or artificially) long-term forest resilience.

Natural vs Artificial Regeneration: When to select between natural regeneration and artificial (i.e., tree planting)?

Summarize how addressing this topic is time-sensitive and urgent for guiding post-fire restoration and recovery.

Member 1	Member 2
This topic is time sensitive for several reasons, (1) because reforestation efforts become more difficult as other non-conifer species take hold, necessitating more site prep and intervention to make sites conducive to seedling success, (2) the occurrence of fires causing large treeless patches is increasing, and (3) post-fire disturbances like wind events, drought, and re-burn all impact the potential trajectories of large treeless patches.	Land managers and other interested parties are making decisions quickly after a wildfire about whether to order seedlings produced in nursery 1-2 years before planting, and weigh considerations about competition with native understory vegetation, safety for crews with trees falling over time, and operational and budget feasibility into the future before they have preliminary or complete information about natural forest recovery. Providing clear, science based decision-making support information to managers about how to proceed in the immediate and intermediate (e.g., 2-10 year) post-fire timeframe will greatly benefit land managers and other interested parties in determining post-fire management actions, especially tree planting.

Suggested revisions, Member 1: *Combine with other topics*
It could potentially be combined with this question “Non-forest Stand Conversion vs Artificial Regeneration: When should we allow ecosystems to convert to non-historic vegetation communities (e.g., grass or shrubs) versus replanting?”
Suggested revisions, Member 2: *Topic Phrasing, Topic Research Questions*
Natural vs. artificial forest regeneration: evaluating natural regeneration potential and determining when to perform tree planting?
What are predicted post-fire recovery trajectories for Western USA forests by forest cover type in an era of changing temperature and drought? Natural vs. artificial regeneration: evaluating natural regeneration potential and determining when to perform tree planting in post-fire dry conifer ecosystems of the Western USA? Natural vs. artificial regeneration: evaluating natural regeneration potential and determining when to perform tree planting in post-fire mesic conifer ecosystems of the Western USA?

Non-forest Stand Conversion vs Artificial Regeneration: When should we allow ecosystems to convert to non-historic vegetation communities (e.g., grass or shrubs) versus replanting?

Summarize how addressing this topic would have a significant impact on guiding post-fire restoration and recovery.

Member 1	Member 2	Member 3
As the climate warms, the growing concern of forest transitions to shrub/grassland ecosystems continues to challenge the science and management communities. Fire, specifically in short intervals, is the prominent influencer for this conversion as it modifies vegetation composition and structure. According to Tepley et al. l(Tepley et al., 2014), conversion of ecosystems to non-forest stands will result in the decline in many ecosystem services and values such as carbon storage, wildlife habitat, biodiversity and water quality. Tepley and associate ecologists recommend that to better assess future vegetation and conversion dynamics, we need to understand the historical post-disturbance regeneration and/or tree establishment in the landscape we are working in. This may require looking into historical data sets and/or communicating with local Indigenous communities that may have historical knowledge of fire behavior and landscape recovery.	While there are numerous studies that illustrate a potential for post-fire ecosystem conversion to a non-historic community, few explicitly address the questions of "when we should allow" or "accept" conversions or perform reforestation activities. Like the proposed question "Natural vs Artificial Regeneration: When to select...", few studies in the western US provide guidance on when replanting may be necessary, and none explicitly articulate when we may want to accept or allow an ecosystem conversion. Further, only one study examined the social, cultural, economic or political questions relevant to the question "when should we allow [forest] ecosystem [conversion]" and none do so for post-fire environments. Critically, while many studies illustrate post-fire forest ecosystem conversions, a clear understanding of where (e.g., forest types and geographically) vegetation conversation are occurring is not synthesized completely in the literature. Where/why post-fire ecosystem conversions are occurring, and when and where we may wish to accept or allow these conversions and many social, economic or operational considerations would be greatly beneficial to land managers.	As conversion becomes an ever-growing concern across burned areas of western US forests (Coop et al. 2020), so does the concern about how to manage these transformed landscapes. Our USFS policy mandates reforestation on all acres that have become "unforested" either because of fire or due to logging (e.g., 16 U.S.C. § 475, 16 U.S.C. § 551; 81 FR 24785). However, there are many areas that may not be suitable for regeneration now or in the coming decades, as our climate continues to warm, and many areas become more arid (Davis et al. 2020). Post-fire ecosystem management should focus on actions that promote an ecosystem with desirable ecosystem properties and that ecosystem type which is viable in the coming decades. Thus, if tree seedling survival is unlikely, then promoting productive, non-forest ecosystems is critical. Understanding where planted tree survival will be low and where the changes in ecosystem properties from a forest to a non-forest ecosystem is acceptable, we can better prioritize our post-fire management practices to ensure the greatest likelihood of success in reforestation efforts and the best outcomes for those areas that will not return to forests.

Non-forest Stand Conversion vs Artificial Regeneration: When should we allow ecosystems to convert to non-historic vegetation communities (e.g., grass or shrubs) versus replanting?

Summarize how addressing this topic is time-sensitive and urgent for guiding post-fire restoration and recovery.

Member 1	Member 2	Member 3
The urgency of reducing the conversion rate of forest-stands to shrublands is time sensitive. According to Tepley et al (Tepley et al., 2018) closed canopy forests have negative feedback on landscapes. When non-stand forest conversions happen in combination with high fuel loads and highly flammable exotic plant materials, vegetation feedback can be altered. Establishment of non-forest stand systems reduces long-term ecological vitality of critical ecosystems that provide benefits in the areas of carbon sequestration, water and wildlife habitat. And equally important is that non-forest stand shrublands can be the impetus for more frequent, higher severity fires leading to losses in critical seed sourcing, hydrology and soil composition for any future recovery. To reduce the conversion rates and percentages of forest-stand loss, human intervention of artificial planting is highly recommended by Tepley et al.	Land managers and other interested parties are making decisions quickly after a wildfire about how to assess natural forest recovery, the potential for ecosystem conversion, and whether to perform reforestation. When considering reforestation activities, managers typically seek to order seedlings produced in a nursery 1-2 years before planting, and weigh considerations about competition with native understory vegetation, safety for crews with trees falling over time, and operational and budget feasibilities into the future before they have preliminary or complete information about natural forest recovery in many cases. Providing clear, science based decision-making support information to managers about how to proceed in the immediate and intermediate (e.g., 2-10 year) post-fire timeframe will greatly benefit land managers and other interested parties in determining post-fire management actions, especially tree planting and or allowing ecosystem conversions to occur.	Understanding when and where to actively reforest is critical with a growing deficit of reforested acres with increasing size and severity of wildfires. There are three reasons this is critical to understand now: 1) the size of areas that could be planted versus our capacity to plant, 2) the cost of planting, and 3) the potential detrimental ecological impacts of unsuccessful planting. Some estimate that <10% of those areas that become unforested every year are replanted. Therefore, prioritizing areas that are likely to convert to non-forest without intervention but could support a forest if trees were planted would ensure the greatest likelihood of success. Replanting is costly (Fargione et al. 2021) thus we should do all we can to ensure a high rate of survival. Finally, active management in post-fire landscapes is critical, but can come with long term implications to the ecology of these landscapes. Recently disturbed ecosystems are often invaded by non-native species (Prevey et al. 2024) and post-fire management actions can increase the invasion (Peppin et al. 2010; Davies et al. 2024), thus only planting when success is likely is critical for ecosystem function.

Non-forest Stand Conversion vs Artificial Regeneration: When should we allow ecosystems to convert to non-historic vegetation communities (e.g., grass or shrubs) versus replanting?

Suggested revisions, Member 1: *Combine with other topics*

Assisted Species Migration - assess how we can support the migration of certain species to new landscapes to reduce conversion %

Suggested revisions, Member 2: *Topic Phrasing, Topic Research Questions*

Non-forest Stand Conversion vs Artificial Regeneration: When should we accept ecosystem conversion to non-historic vegetation communities (e.g., grass or shrubs) versus replanting?

Where are post-fire forest ecosystem conversions occurring geographically, in which forest vegetation types, and why [a synthesis]?
Post-fire forest ecosystem conversions – when and where may we consider accepting conversions and related social, economic, or operational considerations.

Suggested revisions, Member 3: *Combine with other topics*

Potentially could get combined with Climate & seed zone models as this is somewhat the bottom of the elevational zone issue and higher elevations is a question of which trees should be planted where which has a similar justification.

Assisted Species Migration: What are the benefits and drawbacks of assisted gene flow and migration to aid reforestation after fire?

Summarize how addressing this topic would have a significant impact on guiding post-fire restoration and recovery.

Member 1	Member 2	Member 3
Assisted migration (AM here referred to as translocation; see below) exemplifies new strategic responses proposed to maintain biological diversity through a period of climate change. The velocity of climatic change raises concerns that the ability of many species to range-shift in response to changing climate may be constrained under contemporary conditions, including dispersal barriers due to human land use. An intense debate surrounds the translocation option. Objections to its use as "ecological gambling" (Ricciardi and Simberloff 2009) include concerns for inadvertently introducing species that could become locally invasive, displacing native biota (as has occurred multiple times with introductions to islands); lack of essential symbionts (such as pollinators or food plants); contamination of locally-adapted gene pools; and the sheer number of species that may require assistance on a global scale, not to mention the high probability of failure. On the other hand, most land management agencies see little choice in assisting extension of geographic ranges as climate zones shift, and many species being experimented with are not likely to trigger the objections enumerated above.	Currently there is very limited guidance on how, where, and if to implement assisted gene flow and migration (AGF/AM). Barriers to implementing AGF/AM include availability and knowledge of seed sources and uncertainty of outcomes. There is strong evidence for local adaptation of conifers to climate. However, there are major unknowns about the outcomes of implementing AGF/AM, which can be variable or unexpected given the potential tradeoffs inherent in climate adaptation (e.g. drought vs frost tolerance) and because other factors can promote local adaptation (e.g. pathogen resistance). Further, AM is even more complicated given the potential risk of introducing a new species, so detailed risk analyses are needed. While a few large studies of AGF/AM have recently started (ENAMES, AMEX, ASCC), there are still very few studies examining AGF/AM in an operational context in the western US and there is likely a large amount of variability and potential for site-specific responses. To inform management decisions, we need widespread experiments across biophysical gradients with standardized datasets on seed provenance and planting outcomes.	Trees are long-lived and have different climatic thresholds during their life stages. While climate change projections indicate a warmer future, the amount/timing of precipitation are less certain. We have limited understanding about the seasonality and timing of precipitation and growth-climate responses for a vast number of tree species and development stages. Identifying the tradeoffs of tree species/genotypes with resilience to the various climatic conditions of frost, extreme temperatures, and drought conditions will be an important first step. The survivors will contribute climate adapted genetics to the landscape and aid in recovery over the next century. Establishing new tree regeneration now will provide the seed source for the future forest that will be developing under future changed climate. However, several potential drawbacks exist. Adaptive capacity of current populations might be suitable. Introducing new genotypes that are not adapted might increase the maladaptation of the current populations in the future. Furthermore, the introduction of new species to a site might outcompete the local populations, even if those local populations are suitable for the site.

Assisted Species Migration: What are the benefits and drawbacks of assisted gene flow and migration to aid reforestation after fire?

Summarize how addressing this topic is time-sensitive and urgent for guiding post-fire restoration and recovery.

Member 1	Member 2	Member 3
The schedule for translocation is driven entirely by environmental factors. First of these is the velocity of climate change, as expressed in the distance (km/per decade or equivalent) that a given climate envelope is moving, generally up slope and poleward. Second, the timetable is determined by the occurrence of large-scale disturbance events, such as major droughts, insect outbreaks, and wildfires. These punctuated events affect the translocation timetable significantly because in their wake, landscapes remain which may not be suitable for young germinants and seedlings of the species that lived there previously. Under those circumstances, new species better adapted to the current and future climate would reasonably be introduced at this point, constituting a translocation event. The Forest Service is developing policy moving in this direction, but the science basis for translocation is in its infancy.	Addressing this topic is urgent for a few reasons. First, an increasing amount of high severity burned area is planted with conifer seedlings each year. The sooner we can establish guidelines for planting seedlings that will survive now and thrive under changing conditions, the fewer resources that will be wasted planting maladapted tree seedlings. Widespread planting efforts also provide an opportunity to establish experiments in recently burned areas by partnering with agencies and managers who are already planning reforestation projects. Second, surveys suggest that some managers are already using AGF?AM but there are no clear policy frameworks that require climate-adapted planting strategies on public lands in the U.S, in contrast to Canada. We need data to inform better policy and agency frameworks for climate-adapted planting. There is also an opportunity for policy to help create better data by standardizing geographic information collected and retained with seed lots. Third, trees are long-lived and sometimes long-term survival or growth responses to experimental plantings differ from short term responses so it is important to start experiments as soon as possible.	Susceptibility and tolerance of a species to climatic and disturbances changes throughout its development from seedling to mature tree. In the short-term, we need the ability to identify thresholds in climate variables for seedling survival and growth. The expansive range of some tree species provides a range of climatic conditions where local adaptations have evolved. Does photoperiod of a specific provenance influence phenology and change the frost tolerance? In the long-term, as the tree matures, understanding the different climatic thresholds will be important for the sustainability and optimal growth of these forests. Establishment of forests now to be prepared for reproduction in the future is needed. Understanding the tradeoffs of establishing a maladapted tree species or genotype seedling in the current climate with the anticipation that it will be adapted to the future climate when it needs to reproduce is extremely important. The urgency and time sensitivity of establishing a range of tree species and genotypes within a species is high since it will take decades for tree seedlings planted now to reach reproductive maturity.

Assisted Species Migration: What are the benefits and drawbacks of assisted gene flow and migration to aid reforestation after fire?

Suggested revisions, Member 1: *Topic Phrasing*

The preferred term would be translocation, assisted colonization, or assisted dispersal. Strictly speaking, migration refers to cyclic or seasonal movement, not permanent relocation.

Suggested revisions, Member 2: *NONE*

Suggested revisions, Member 3: *Combine with other topics*

Climate & seed zone models: How do we develop seed-transfer guidelines and seed zones in light of a changing climate?

Species & Genetic Sources for Climate-Smart Reforestation: What tree species and genetic sources increase the potential for forest diversity and adaptability for future climates?

Summarize how addressing this topic would have a significant impact on guiding post-fire restoration and recovery.

Member 1	Member 2	Member 3
Typically, tree nurseries acquire seeds from specialized seed orchards which prioritize disease resistance as the majority of seed is for the replacement of commercial timber stocks. Recent declines in investment in seed source procurement has increased the reliance on relatively few seed sources with limited generic and geographical diversity. Seed from these sources is likely unsuited to the harsh climatic conditions in post-wildfire areas and may contribute to the low seedling survival in such environments across the southwest. As just ~20% of current seedlings are produced from wild-collected seeds, there is a pressing need to diversify seed source collection and identify potential sources that may increase forest resilience to future climate conditions. The latitude and elevation of an individual tree governs its intrinsic water use efficiency and growth, and some supporting evidence suggests seedlings propagated from specific trees reflect these differences. Identifying seed sources which produce robust, resilient seedlings for outplanting could greatly increase post-wildfire reforestation success.	Trees are known to vary in their ability to tolerate high temperatures and droughts both across and within species. Some species distributions are widespread and have high genetic plasticity. In contrast, some species are isolated to specific climatic conditions and have low genetic plasticity. Response to drought might also differ among tree species. For example, trees species from water limited environments vs energy limited environments might have different approaches to drought conditions (i.e. isohydric or anisohydric). To ensure forest diversity, reforestation activities will need to include the more popular, generalist species as well as the isolated, specialist species such as rust-resistant 5 needle pines. This would include commercial timber species and non-commercial tree species. A better understanding of future disturbance regimes will also be important. Establishment of a new forest is the goal for the present, but we need to consider the ability for the future forest to still reproduce and establish new seedlings under a new disturbance regime.	Trees are long-lived and have different climatic thresholds during their life stages. While climate change projections indicate a warmer future, the amount/timing of precipitation are less certain. We have limited understanding about the seasonality and timing of precipitation and growth-climate responses for a vast number of tree species and development stages. Identifying the tradeoffs of tree species/genotypes with resilience to the various climatic conditions of frost, extreme temperatures, and drought conditions will be an important first step. The survivors will contribute climate adapted genetics to the landscape and aid in recovery over the next century. Establishing new tree regeneration now will provide the seed source for the future forest that will be developing under future changed climate. However, several potential drawbacks exist. Adaptive capacity of current populations might be suitable. Introducing new genotypes that are not adapted might increase the maladaptation of the current populations in the future. Furthermore, the introduction of new species to a site might outcompete the local populations, even if those local populations are suitable for the site.

Species & Genetic Sources for Climate-Smart Reforestation: What tree species and genetic sources increase the potential for forest diversity and adaptability for future climates?

Summarize how addressing this topic is time-sensitive and urgent for guiding post-fire restoration and recovery.

Member 1	Member 2	Member 3
Seedling traits that may increase the likelihood of seedling survival and growth when outplanted in potentially thermally challenging environments, such as thick cuticle, deep root systems or adaptable root architecture, high xylem conductance, low specific leaf area, low stomatal density, low relative stomatal conductance or wind-resistant growth forms. The origins of these potentially advantageous traits, either through genetic inheritance or adaptation to environmental factors, can then be targeted, and potentially amplified through conditioning or selective seed collection or propagation. By quantifying such traits and relating their expression frequency and strength to differing seed sources, greenhouse conditioning, and outplanted seedling performance, seedlings expressing particular traits can be selected for specific reforestation sites, and microsites within them, to collectively maximize seedling growth and survival rates across planting sites. This important research takes time, and should be tackled as soon as possible to maximize reforestation success before land-type conversions	We need to start now to get a better idea of how different genotypes and species will respond at different stages of development. Identification of the commercial and non-commercial timber tree species that are best adapted physiologically to future climate and disturbance regimes will be needed to ensure climate-smart reforestation. To understand how these species mixes might interact together through competition/facilitation will be needed for future forest management. Identifying species with similar ecological functionality but better adaptation to future climates to replace current maladapted species is needed now. Furthermore, the seed sources that cover the gradient of future climates might be missing from the current nursery seed inventory. These sources might also be at high risk of loss as a result of wildfire, insects/disease, or harvests. Identifying future adapted species/genotypes, their locations, and their prevalence in the nursery seed inventory will aid in the prioritization of seed collection and preservation of these important sources. These activities will promote diverse and adaptive forests for the future.	Susceptibility and tolerance of a species to climatic and disturbances changes throughout its development from seedling to mature tree. In the short-term, we need the ability to identify thresholds in climate variables for seedling survival and growth. The expansive range of some tree species provides a range of climatic conditions where local adaptations have evolved. Does photoperiod of a specific provenance influence phenology and change the frost tolerance? In the long-term, as the tree matures, understanding the different climatic thresholds will be important for the sustainability and optimal growth of these forests. Establishment of forests now to be prepared for reproduction in the future is needed. Understanding the tradeoffs of establishing a maladapted tree species or genotype seedling in the current climate with the anticipation that it will be adapted to the future climate when it needs to reproduce is extremely important. The urgency and time sensitivity of establishing a range of tree species and genotypes within a species is high since it will take decades for tree seedlings planted now to reach reproductive maturity.

Suggested revisions: *NONE*

Climate & seed zone models: How do we develop seed-transfer guidelines and seed zones in light of a changing climate?

Summarize how addressing this topic would have a significant impact on guiding post-fire restoration and recovery.

Member 1	Member 2
The development of seed-transfer guidelines and seed zones would take years if done in classical genetic testing. The reality is that we simply don't have the time or funds to do so because trees are such long-lived species. Considering this, scientific models are being developed based on environmental factors that influence tree growth. Several models are currently in use such as, the Seedlot Selection Tool and the Climate-Smart selection tool. These models could use support to enhance development and user experience. As well, models could use some expansion in geographic area and species. Newer models could integrate more geographical, vegetation, and soil layers to map seed zones. Though new models may employ a diversity of layers and databases, classical testing of plant phenology is still valuable. Long-term provenance studies will provide detailed species data for the future, and short-term genecolgical can provide detailed species data in the interim.	Without climate adaptation in reforestation, the combination of rapid climate change and increased fire activity suggest that can expect higher rates of planting failure (e.g., Koehn et al. 2022) and simpler, less diverse landscapes. Congress passed the Repairing Existing Public Land by Adding Necessary Trees or REPLANT Act into law in November of 2021 which sets a clear mandate to address post-wildfire and other reforestation needs and increases resources for tree planting by removing the funding cap of the Reforestation Trust Fund. The Forest Service is also updating reforestation policy within the silviculture manual (FSM 2470) to make clear allowances for climate-smart reforestation and assisted migration (climate smart). Predictive models calibrated only to climate envelopes likely forecast greater declines than those that also consider forest structure (Dowbrowski et al. 2015) owing to the ability of mature tree canopies to mitigate declines inferred by climate alone. The importance of the overstory as a seed source and in buffering microclimates to overarching warming trends hinges on the absence of stand replacement disturbance (Elias et al. 2015, Hill and Field 2021).

Climate & seed zone models: How do we develop seed-transfer guidelines and seed zones in light of a changing climate?

Summarize how addressing this topic is time-sensitive and urgent for guiding post-fire restoration and recovery.

Member 1	Member 2
Wildfire impacts are becoming more severe and widespread across North America. At the same time, changing climate is exacerbating the challenges associated with revegetation efforts following fire. While long-term studies on seed transfer zones will provide great detailed data for future models, we don't have time to wait for the data, much less the capacity to study a large number of species, for use now. Improved modeling shows promise in the interim and allows us to extrapolate across a diversity of species.	Paleoecology suggests that, without assistance, the current rate of climate change is outpacing the landscape's rate of adjustment, with late-seral species taking even longer to adjust (Axelrod 1958, Cole 2010, Laughlin et al. 2011) and with high-severity fire catalyzing long-term change with each event. Conventional reforestation that assumes the adaptive capacity of ponderosa pine or that seed collected at a given elevation zone will still be adapted to that elevation zone, let alone with additional warming, is likely to result in greater planting failure than reforestation that is at least climate-informed. Assisted migration is the human-assisted movement of species, populations, or genotypes outside of their characteristic geographic distribution for purposes of maintaining ecosystem diversity and function (Richardson et al. 2009, Schwartz et al. 2012). Assisted migration has been categorized as either assisted population migration, assisted range expansion, or assisted species migration. Assisted migration is addressed in the draft revision of Forest Service reforestation directives. While the new policy is still in draft managers can nevertheless move forward now with cross-zone seed collection and outplanting knowing that reaching scale for future reforestation work could take five years from the date of collection.

Suggested revisions: *NONE*

HYDROLOGY

Erosion Mitigation: What pre- and post-fire management actions are most effective to mitigate soil loss post-fire?

Summarize how addressing this topic would have a significant impact on guiding post-fire restoration and recovery.

Member 1	Member 2
In the western US, post-fire erosion treatments can be broadly categorized into three groups: 1) mulching or other ground cover application; 2) building physical barriers in streams and/or on hillslopes to prevent or redirect sediment-laden runoff; and 3) seeding to promote vegetation recovery. The efficacy of each differs significantly depending on the terrain, rainfall regime, severity of the burn, and the application time frame. However, with the increasing likelihood of sites reburning or burning at higher severity than historically was seen, combined with the increasing likelihood of other natural hazards occurring right before or after a burn event (e.g., extreme storm events, droughts) leaves questions about how and when these techniques should be used to be most effective. Work that builds a better empirical base of knowledge through field work, combined with information that can be gained by remote sensing or through soil erosion models will likely significantly help improve the effectiveness of such treatments.	About 90% of the total economic costs of wildfire take place after fire occurrence, due to processes such as flooding and soil movement (Barrett 2018, Hjerpe et al. 2023). Elevated discharge from burned watersheds lasts about six years, on average (Williams et al. 2022), but loss of soil materials and nutrients can continue to occur after this point, degrading vegetation productivity and water quality (Rhoades et al. 2019). Emergency response programs such as BAER are designed to help address these issues, by limiting soil erosion and runoff, but certain treatments can be more effective than others (Girona-García et al. 2021). Application of mulch is generally effective at reducing soil movement and runoff (Wagenbrenner et al. 2006), whereas seeding and construction of hillslope stabilization structures may be less effective, particularly under high precipitation events (Robichaud et al. 2008, Peppin et al. 2010). Because extreme rainfall events can hinder vegetation recovery (Crockett and Hurteau 2024) and cause substantial amounts of soil movement, the impacts of different treatments during extreme rainfall events is an important research need (Lopes et al. 2020).

Erosion Mitigation: What pre- and post-fire management actions are most effective to mitigate soil loss post-fire?

Summarize how addressing this topic is time-sensitive and urgent for guiding post-fire restoration and recovery.

Member 1	Member 2
With the increasing frequency and severity of wildfires fueled by the changing climate, soil erosion will continue to be a major challenge to watershed management. Delaying the use of effective soil erosion control techniques can lead to irreversible soil degradation, deteriorated water quality, and habitat loss, making post-fire restoration more difficult and costly. Soil erosion is particularly important during the first few post-fire years when burned areas experience maximum erosion especially when aided by factors like high-intensity rainfall and wind. While much research has gone towards understanding the short-term effectiveness of soil erosion control measures, there are some methods that need to be studied in more depth to determine whether they are net positive contributions to mitigating soil erosion. This includes whether some treatments (e.g., some chemicals / fertilizers) further reduce water quality, and whether other treatments, like mulching, inhibit vegetation recovery and promote invasive plant recruitment and growth. More work on what the effectiveness is of combined treatment approaches is explicitly needed as well.	Post-fire flooding and soil movement can have significant economic and ecological impacts. This is particularly true in the US Interior West, where the WUI is rapidly expanding (Radeloff et al. 2018) and severe wildfire activity is increasing (Parks and Abatzoglou 2020). Agricultural and residential water use in the US West is heavily reliant on forested headwaters and reservoir systems – which are particularly sensitive to severe fire and sedimentation (Barnard et al. 2023). Understanding how pre-fire treatments can influence outcomes such as post-fire flooding and soil movement (i.e., by reducing fire severity), will help to develop a more accurate estimate of return on treatment investment (Hjerpe et al. 2024). Similarly, understanding which post-fire management strategies are most effective, particularly under extreme precipitation events, will help to allocate financial resources in immediate post-fire response and longer-term mitigation activities.

Suggested revisions, Member 1: NONE

Suggested revisions, Member 2: *Combine with other topics*

Yes - This feels like it could be merged with topic on post-fire flooding and debris flows. Many of the same treatments are used to limit flooding, debris flows, and erosion

Flooding & Debris Flow Mitigation: What pre- and post-fire management actions are most effective to mitigate flooding and debris flows post-fire?

Summarize how addressing this topic would have a significant impact on guiding post-fire restoration and recovery.

Member 1	Member 2
Two pre-fire actions in the literature to potentially reduce the magnitude of post-fire flooding and debris flows is fuels management and beaver dams or beaver dam analogs to reduce fire severity or area burned respectively. Other pre-fire mitigation efforts are focused on reducing loss of life and property post-fire without influencing the magnitude of the fire or the subsequent flooding or debris flows. The pre-fire uncertainty of burn area and severity, and post-fire uncertainty of precipitation area and intensity suggest that relatively inexpensive actions, actions with widespread benefit, or complicated actions that can't be effectively implemented between the fire and the flooding should be considered pre-fire. Depending on the site in question these may include fuels reduction, beaver dam analogs, and installation of debris net anchors in rock outcrops (with design/sizing of nets for procurement post-fire).	

Flooding & Debris Flow Mitigation: What pre- and post-fire management actions are most effective to mitigate flooding and debris flows post-fire?

Summarize how addressing this topic is time-sensitive and urgent for guiding post-fire restoration and recovery.

Member 1	Member 2
If there are additional strategies besides fuels reduction that should be considered for mitigation of post fire debris flows, the sooner we understand their relative benefit, the sooner we can more efficiently utilize our limited pre-fire mitigation resources.	

Suggested revisions, Member 1: *Topic Research Questions*
Should the next pre-fire mitigation dollar be spent on fuels management, beaver dam analogs, reservoir bypass channels, geo-brugg anchors, or something else? (This is probably too specific, but as a utility director this is really what we would like to know.)
Suggested revisions, Member 2: *NONE*

Snowpack & Water Quantity: What are the impacts of fire on snowpack and water quantity?

Summarize how addressing this topic would have a significant impact on guiding post-fire restoration and recovery.

Member 1	Member 2
There is great uncertainty in how fire impacts snowpack and water quantity due the complexity of interacting factors. Fire of different severities and pattern will change forest structure, which will then change snowpack accumulation and duration by impacting shortwave and longwave radiation, albedo, interception, and transpiration. These interactions will be further modified by the aspect, burn pattern and size, and climate of the impacted forest, ultimately resulting in some cases where fire increases snowpack and water quantity, and other cases where it decreases. Advancing knowledge on the topic would guide post-fire restoration and recovery actions by informing whether the resulting post-fire forest is likely to be beneficial or detrimental to snowpack and water quantity. For example, in some locations and at some fire sizes and severity, it may not be beneficial to replant trees because the results post-fire forest structure is optimal for snow accumulation. In other cases, replanting trees, reducing erosion, or modifying post-fire albedo could be important for maintaining or increasing snowpack and water quantity.	Water managers in the Colorado and Rio Grande basins have invested in predicting spring runoff volumes from snowpack measurements (snow water equivalent). These forecasts inform agricultural and municipal planning. However, uncertainty in wildfire-affected watersheds can lead to overestimating water supply, increasing the risk of shortages and tensions among water rights holders. Recently, interest has grown in how pre- and post-fire actions can enhance snowpack and boost spring runoff. Studies like Giovando (2022) found that wildfires reduce annual maximum SWE by about 10%. Additionally, Reis et al. (2024) found that increasing wildfire frequency and intensity in high-elevation areas impacts snow accumulation and melt patterns, with faster melt rates varying by slope orientation. The Bureau of Reclamation has begun studies in the San Juan headwaters to evaluate snowpack variations in pre- and post-fire areas for better fire planning. Research on post-fire treatments to mitigate changes in SWE and melt rates will improve runoff forecasting, leading to more informed water management decisions.

Snowpack & Water Quantity: What are the impacts of fire on snowpack and water quantity?

Summarize how addressing this topic is time-sensitive and urgent for guiding post-fire restoration and recovery.

Member 1	Member 2
Several recent meta-analyses and regional studies have made it clear that there is consensus on the mechanisms involved but not the sum total of how they interact. Understanding these interactions is critical to accurately predicting the implications of post-fire restoration and recovery on snowpack and water quantity. One factor is clear – the impact of fire on snowpack and water quantity---both positive and negative---tends to be more extreme in lower-latitude forested regions (e.g. the Southwest) where water is also most scarce and where fire regimes are also rapidly intensifying. Thus, it is time-sensitive and urgent in these regions in particular to advance knowledge on this topic.	There is a pressing need, particularly in the Colorado River Basin, to quantify future water availability. Efforts are underway to secure funding from federal agencies for fire planning, pre-fire treatments, and post-fire restoration. Demonstrating how these initiatives can increase water quantities in the river system will help support project funding. This approach will also assist federal agencies, such as the U.S. Forest Service, in justifying the need for costly NEPA compliance required for post-fire restoration on federal lands. Having data that links water quantity to post-fire restoration is crucial for leveraging funding opportunities at local, state, and federal levels.

Suggested revisions: *NONE*

Watershed Recovery Times: What factors explain variation in watershed recovery time and trajectory after a fire?

Summarize how addressing this topic would have a significant impact on guiding post-fire restoration and recovery.

Member 1	Member 2
Advancing our understanding of why watersheds recover from fire at different rates, and whether they are likely to recover to the previous or a new state, would significantly impact post-fire restoration strategies by informing the need and time window in which restoration can or should be applied. For example, if we can anticipate that a watershed will recover quickly due to attributes that lend it resilience, expensive restoration strategies should not be applied. If, on the other hand, we can anticipate that the watershed will recover on a non-linear trajectory to a new and undesirable state, this would provide justification for swift and aggressive action to prevent the new state from being realized. In some cases, we may be able to anticipate that the watershed will recover to a desirable state, but that it will take decades without intervention. It can then be assessed whether that time window is acceptable or if restoration activities to speed up recovery are warranted. Finally, if we identify factors that speed recovery or prevent state changes, those factors could be encouraged in restoration strategies.	Post-fire forest recovery takes decades or longer, but the variation in recovery time is difficult to predict, as is the likelihood of returning to the pre-fire condition vs. shifting to a different vegetation community. Better estimates of recovery times and trajectories across the landscape would enable more intentional resource allocation toward assisting the recovery process, for example as an input to triage decisions. Alternatively, critical areas (e.g., municipal watersheds) that might be predicted to have long recovery times or be at risk for unfavorable vegetation conversion could receive extra attention in an attempt to assist the recovery process. But the great many processes or factors that affect recovery make such forecasting and decision making difficult. How do factors such as slope, geologic substrate, fire history, and precipitation seasonality interact to affect metrics like seedling establishment frequency or forest regrowth rates? Extensive, systematic research is necessary to tease apart the many potential controls.

Watershed Recovery Times: What factors explain variation in watershed recovery time and trajectory after a fire?

Summarize how addressing this topic is time-sensitive and urgent for guiding post-fire restoration and recovery.

Member 1	Member 2
I think I addressed this in the previous response. Explaining variation in watershed recovery time and trajectory is one of the most fundamental topics on which we need to advance our knowledge to effectively guide post-fire restoration and recovery. Without this understanding, it will be impossible to optimize restoration strategies. Money will be wasted apply restoration strategies where none are needed, and restoration strategies will be less effective because they haven't been informed by factors that confer resilience in watersheds.	Burn area emergency response teams and long-term forest managers have to make treatment/action decisions after every fire. The sooner useful information can be provided, the great the chance that sizeable areas will be able to recover to something approaching the pre-burn state in human timescales. With that said, many such decisions can be made with partial information and still be expected to have a reasonable level of success. Recovery time information is probably not the limiting factor in rehabilitating burned areas.

Suggested revisions, Member 1: *Topic phrasing, Topic Research Questions*

Watershed Recovery Times and Trajectories: What factors explain variation in watershed recovery time and trajectory after a fire? (Alternatively, get rid of Times and just have Trajectories)

This is a very broad topic and what I wrote is generalized to watershed recovery in terms of the terrestrial landscape, the aquatic landscape, and the transfer of material between. However, it would be possible to provide more specifics if the topic of recovery of hydrology, water quality, forest structure, etc. were specified. For example, hydrologic changes can persist for decades following fire (Niemeyer et al. 2020, Williams et al. 2022) with variation in duration of effects attributed to the extent and severity of fire (Hallema et al. 2018, Wagenbrenner et al. 2021) and rate of vegetation regrowth (Tague et al. 2019). However, other aspects of recovery are more complex and less well understood.

Suggested revisions, Member 2: *NONE*

Predictive models for watershed response: How can we improve watershed prediction tools for post-fire hydrological events?

Summarize how addressing this topic would have a significant impact on guiding post-fire restoration and recovery.

Member 1	Member 2
Erosion prediction tools, such as the Forest Service's Water Prediction Project (WEPP), allow decision makers and managers to predict post-wildfire effects on watersheds. These tools can assess the risk of flooding, sedimentation, etc. in order to make operational decisions that influence erosion reduction and public safety post-fire. While this suite of tools is operational, improvements are needed to ensure accuracy and usefulness. First, there is a need to validate the tools in more geographic settings to ensure they accurately predict wildfire-watershed effects across geographies. This requires field data collection immediately after wildfires. A second need is to expand the area over which soil burn severity is mapped post-fire. Burn severity maps are a key input into WEPP and typically collected by federal Burned Area Emergency Response (BAER) teams. However, BAER teams are currently limited to assessing burn severity on federal or Tribal lands. Expanding the mandate of these teams to conduct cross-jurisdictional burned area risk assessments would have an impact on the ability to predict post-fire erosion.	Recent review papers on modeling post-fire hydrologic response highlight numerous gaps and opportunities for improvement. Partington et al. (2022) highlights the need to "quantitatively assess the spatiotemporal extent of the wildfire-induced impact on hydrological functioning, tracking changes to fluxes in the chain of processes from precipitation to runoff." Partington et al. (2022) also describe needs to better understand short-term, medium-term, and long-term post-fire hydrologic responses to be able to plan for flood risk and water quality-impacts, water availability, and water infrastructure. Limitations in using physically-based models for post-fire recovery and restoration include lack of hydrologic models designed specifically for post-fire application, lack of guidance for using hydrologic models for post-wildfire application, inadequate representation of groundwater flow, subsurface flow, and soil-water processes, inadequate application for vegetation regrowth, and lack of access to computational resources (Ebel et al, 2023). Addressing these limitations and weaknesses could provide significant impact in guiding post-fire restoration and recovery.

Predictive models for watershed response: How can we improve watershed prediction tools for post-fire hydrological events?

Summarize how addressing this topic is time-sensitive and urgent for guiding post-fire restoration and recovery.

Member 1	Member 2
Improving predictive tools like WEPP is time-sensitive in that data collection for additional WEPP validation and burn severity mapping needs to happen immediately after a fire. Thus, funding and equipment need to be in place, and ready to deploy with enough flexibility where wildfires occur in the western US. The topic is also urgent because if these models can be verified in more geographic regions and if data on burn severity can be collected across jurisdictions after a fire, then these tools can be used with more confidence to inform decision making and protect public safety.	If models were in a closer state to be able to be applied as decision tools for post-fire restoration and recovery, this topic may have been more urgent to address. However, because of the numerous limitations of using predictive models for hydrologic response, short term attention might be better spent on other approaches while still keeping improving these models as a long-term goal.

Suggested revisions, Member 1: *Topic Research Questions*

How can we deploy rapid and cross-jurisdictional data collection efforts post-fire to improve watershed predictive tools?

Suggested revisions, Member 2: *NONE*

Process Based Stream Restoration: What is the effectiveness of post-fire stream restoration on floodplain processes, including carbon storage, groundwater storage, and sediment accretion?

Summarize how addressing this topic would have a significant impact on guiding post-fire restoration and recovery.

Member 1	Member 2
Almost nothing has been published regarding benefits, challenges, and scientific guidance regarding river corridor restoration following wildfires. River corridor restoration includes restoration of river channels and floodplains. With billions of dollars spend on restoration int the U.S. annually and wildfire occurrences increasing, addressing this topic is important for guiding scientifically-based management of headwater systems following wildfires. Gaps in our understanding of post-wildfire river corridor restoration include responses of aquatic communities (e.g., fish, macroinvertebrates); impacts on river-floodplain and river-floodplain-groundwater connectivity; impacts on water deliveries to downstream water users; role of restoration on carbon sequestration; impacts on water quality and sediment delivery; and riparian forest responses following wildfires and restorations.	Stream corridors are one of the most hard-hit portions of a landscape following fire, both in terms of habitat and human habitations, due to post-fire floods and debris flows. Restoring these channel areas is necessary to reduce continued impacts (water quality, flooding) to downstream communities. Different techniques include hard-engineering (levees, riprap, grade control structures), process-based restoration (water and sediment detention ponds, floodplain reconnection, wood jam reintroduction), and others. Each has strengths and weaknesses in terms of cost, durability, longevity, and effectiveness. Systematic research to identify situations that are appropriate for each technique, and the expected costs and benefits of implantation in any given scenario would save money and enhance ecosystem recovery. These riparian habitats are a hotspot for biodiversity in most regions, so highly effective restoration here would have outsized impact on overall ecosystem health.

Process Based Stream Restoration: What is the effectiveness of post-fire stream restoration on floodplain processes, including carbon storage, groundwater storage, and sediment accretion?

Summarize how addressing this topic is time-sensitive and urgent for guiding post-fire restoration and recovery.

Member 1	Member 2
Post-wildfire stream restoration often occurs within the first three years of a major wildfire to mitigate the largest hydrologic and geomorphic consequences of degraded streams, such as large sediment loads or flash floods. Scientific guidance needs to be well established so that forest managers can quickly implement best practices for stream restoration following a wildfire. With wildfires growing in spatial extent and severity, developing guidelines for implementing stream restoration treatments during wildfire recovery periods is needed as soon as possible. Using the Colorado Front Range as an example, tens of millions of dollars is being spent on restoration with little scientific guidance, and I'm are similar challenges exist in other regions of the IMW.	When riparian and floodplain systems remain impaired following fire, recovery of the biota is expected to be notably delayed. Stream restoration is often not attempted due to the risk of having expensive works washed away by a single major storm. If the benefits of stream restoration are going to be realized, there need to be clearer cost-benefit and reliability estimates for decision-makers.

Suggested revisions, Member 1: NONE

Suggested revisions, Member 2: *Topic phrasing*

Process Based Stream Restoration: What is the effectiveness of various post-fire stream restoration techniques on habitat restoration and floodplain processes, including carbon storage, groundwater storage, and sediment accretion?

SOCIAL SCIENCE

Community Resilience & Recovery: What are the impacts of wildfire across different types of communities and what shapes a community's recovery process?

Summarize how addressing this topic would have a significant impact on guiding post-fire restoration and recovery.

Member 1	Member 2
Researchers and practitioners need to be aware of the factors that influence recovery in the short and long-term so that policies guiding recovery address the particular needs and concerns of communities impacted. Unfortunately, there is very little research addressing the potential impacts of wildfire across different types of communities and the drivers that shape a community's recovery process (Paveglio et al., 2015; Thomas et al., 2022; Morgan et al., 2024). Consequently, our understanding of solutions lack nuance that are sensitive to different contexts (e.g., demographic, economic, geographic, historical). Additionally, the research that does exist largely centers on the drivers that influence recovery in the Wildland Urban Interface (WUI) (Thomas et al., 2022), which tends to de-center factors related to social justice and historical harms that disproportionately impact underserved and marginalized communities (Akter & Grafton, 2021), including land-based communities in rural places that experience unique economic impacts (e.g., the Hermits Peak Calf Canyon Fire, NM in 2022) as well as more urban centers. (e.g., the wildfire that devastated Lahaina, HI in 2023).	Social and ecological recovery after wildfire are interconnected (Kooistra et al 2018). Engaging additional research on community resilience and recovery presents opportunities to more comprehensively plan and manage for the diverse needs and timelines that emerge for recovery decision-making and assistance programs over time. This includes the needs of residents, private landowners, local government, and local businesses among other entities, and the ways in which their impacts, access to resources, and recovery trajectories vary. Advancing understandings of resilience would provide opportunities and best practices to better "live with fire," including minimizing losses and impacts during a fire event and increasing tolerance of mitigation strategies, which in turn reduces the complexity of public safety during fire events (Schumann et al. 2020, Mockrin et al. 2022). Advancing understandings of recovery would support more place-based programing and resources that better align with local needs after fire, minimizing impacts to wellbeing, economy, and infrastructure among other social factors.

Community Resilience & Recovery: What are the impacts of wildfire across different types of communities and what shapes a community's recovery process?

Summarize how addressing this topic is time-sensitive and urgent for guiding post-fire restoration and recovery.

Member 1	Member 2
Having frameworks for recovery that are sensitive and responsive to community-scale factors is necessary both for mitigating (in a pre-fire planning context) and recovering with communities. The fact that we currently lack such frameworks makes this topic time-sensitive and urgent. To this, I would add the ethical imperative of centering environmental justice concerns in post-fire recovery in order to address the often unseen (and unaccounted for) slow violence that continues to impact some communities well after the emergency response phase has ended along with the media attention and funding of federal and state agencies.	Improving community resilience and recovery is paramount as loss of life, infrastructure, and social connectivity continue to increase internationally. Federal agencies like FEMA are repeatedly critiqued for their inability to adequately address the diversity of needs emerging after wildfires, signaling the need for empirically driven, systemic change to how the process of community recovery is designed, tailored, and implemented in socially and ecologically varied corners of the US (Edgeley and Paveglio 2017. While research to date has successfully established how communities perceive of recovery assistance and the process they navigate (Carrol et al. 2006, Edgeley and Paveglio 2017), less is known about more complex elements such as how recovery events compound in regions with frequent fires and limited capacity, unmet needs and inequities that emerge or are exacerbated during recovery, and the extent to which non-governmental and government entities have the ability to support post-fire recovery as wildfire becomes more frequent while funding and staff to support recovery is unstable (Edgeley 2022, Moloney et al. 2023, Chase and Hansen 2021).

Suggested revisions, Member 1: *Combine with other topics*
Combine with Equity: How can we design post-fire recovery programs and processes to be equitable, inclusive, and attentive to social justice issues?
Suggested revisions, Member 2: *Topic Phrasing, Combine with other topics*
Focus on either community resilience or community recovery; these are two somewhat distinct and different ideas with their own bodies of literature.
Could possibly be combined with community engagement.

Community Engagement: How can we better engage communities in restoration and recovery efforts and what are the barriers?

Summarize how addressing this topic would have a significant impact on guiding post-fire restoration and recovery.

Member 1	Member 2
Post-fire recovery is an essential part of community and ecological well-being. As fire and flooding become normal patterns of our environment, it's imperative to engage with communities on both mitigation and restoration practices. Knowledge and suggestions from communities can influence mitigation and restoration planning and methods that can eventually lead to healthier relationships. According to a 2008 journal published by Ryan, R & Hamlin, E. (Ryan & Hamin, 2008), engaging with community members in post-fire landscapes or fire-adapted ecosystems are very interested in engaging with local management agencies on mitigation strategies to reduce future severity fires and promote recovery. This study also illustrated both short-term and long-term successes towards effective restoration practices done in collaboration with communities. Through collaboration, key features such as but not limited to; road access, funding and staging areas were instrumental for restoration to take place.	Community engagement during post-fire restoration & recovery has social and ecological benefits, including: 1) Improved wellbeing and repaired place attachment that comes with public engagement in activities such as replanting burned areas in or adjacent to an affected community (Burns et al. 2008), 2) heightened public engagement in land management decision makings, including attendance at public meetings and more defined partnerships between local interest groups and agencies (Ryan & Hamin 2008), and 3) improved public understandings of how federal postfire processes such as BAER work, which can improve public understanding during and after future fires (Edgeley 2023). Addressing this topic would allow greater alignment between community and ecological recovery activities and a clearer understanding of how the two affect one another. Leveraging the support of community organizations and local governments in restoration and recovery may be necessary as federal agency budgets continue to decrease. It would also improve preparation for cascading hazards in planning efforts for post-fire recovery, particularly postfire flood risk to nearby communities (Colavito et al. 2023).

Community Engagement: How can we better engage communities in restoration and recovery efforts and what are the barriers?

Summarize how addressing this topic is time-sensitive and urgent for guiding post-fire restoration and recovery.

Member 1	Member 2
Fires and flooding are inevitable and expected to happen again. Now that we have learned the dynamics of their behaviors and can trace their patterns, it's important to have these engagement practices with communities. Even before a fire or flash flood, we need to co-strategize and co-implement mitigation and recovery plans for any future events. The co-development of plans will give a greater understanding for community members to value mitigation plans and give them co-ownership thus reducing any future litigation or political challenges. Local people and communities, such as Indigenous communities hold years of ecological and mitigation knowledge of how they have adapted to climatic events in the past. One key barrier that needs to be addressed in this topic is how to rehabilitate strained relationships between land management agencies and communities. I found countless examples of global community engagement resources and tools where land management and scientists collaborated with communities on post-fire recovery. Examples provided were that groups approached communities with a non-scientific viewpoint, listened and learned and provided resources for knowledge sharing.	Community engagement in post-fire activities now is critical for improved response after future fires. Establishing the social "infrastructure" for subsequent fires (e.g. long-term recovery groups, volunteer organizations engaged in landscape recovery) can accelerate and streamline recovery after future fires (Edgeley 2022, Edgeley and Paveglio 2017). A commitment to engaging the public now can also reduce misunderstanding about federal processes after fire – specifically, misconceptions of how decisions are made and what funding is used for – to minimize conflict related to government management of recovery during future fires (Burns et al. 2008). Additionally, given the growing cost of mitigation for post-fire hazards like flooding, engaging private property owners in cross-boundary planning and responses is urgently needed to pro-actively minimize losses (Hjerpe et al. 2023; Burnett and Edgeley 2023).

Suggested revisions, Member 1: *Combine with other topics*
Yes - community resilience and recovery
Suggested revisions, Member 2: *Topic Phrasing, Topic Research Questions, Combine with other topics*
Possibly to focus on either community engagement in recovery or restoration. The text above is more restoration leaning.
What role can the public play in landscape recovery after wildfires? How can common misunderstandings about post-fire recovery be dispelled in order to improve local cohesion?
Could possibly be combined with community resilience and recovery.

Public Support: What are public perceptions of forest and watershed restoration practices?

Summarize how addressing this topic would have a significant impact on guiding post-fire restoration and recovery.

Member 1	Member 2	Member 3
Understanding public support of post-fire restoration and recovery (R&R) practices would have significant impact by ensuring social acceptance of the most effective R&R practices. Wildfire managers have been faced with public backlash in the past, around topics like prescribed fire and salvage logging, that has prevented the implementation of best practices. Thus, understanding public support can inform outreach and education efforts that focus on communicating best practices and addressing risks. The aim of this information is to increase support and acceptance of management practices and to reduce barriers to implementing management practices. The research on public support for wildfire management has focused on the factors that influence support (e.g., trust, values, beliefs) and finds strong links between engaging the public and support for management decisions. However, the literature on this topic acknowledges that true stakeholder engagement in wildfire management remains a challenge.	Public support for land management agencies' forest and watershed restoration practices can shape which approaches are considered and implemented. There is a relatively robust body of research examining public perceptions of forest restoration. In a 2023 review of wildfire social science research in the Southwest, for example, Edgeley argues that public perceptions of forest treatments were one of the most studied areas. Recent research has demonstrated that there is relatively strong support for a variety of forest management practices, including the use of beneficial fire, and that this support is not strongly swayed by large wildfire events (i.e., New Mexico's Hermits Peak Calf Canyon fire or Flagstaff's Tunnel or Pipeline fires) (Colavito et al. 2023; Edgeley and Colavito 2020; Western Voters survey on beneficial fire 2023). There is room for increasing understanding, however, in perceptions of specifically post-fire treatments; perceptions of treatments among understudied populations or in understudied regions or habitats; and how managers are affected by their perceptions of public opinions (building upon Steelman and McCaffrey 2011).	Following the Hermits Peak fire in Mora County, several counties and municipalities-imposed bans on prescribed burns. In San Juan County, Colorado, county commissioners mandated fire suppression for any fire within their borders. This not only restricts prescribed burns but also limits the use of fire for habitat restoration. These policy changes stem from public concerns about fire mitigation and are altering approaches to wildfire risk management. A study in the Journal of Environmental Management examined perceptions of prescribed fire among the public and managers (Wu et al., 2022). Additionally, recovery efforts after costly, high-profile fires have heightened public awareness of forest restoration, especially in areas with limited knowledge of the practice. A study in North-central Arizona revealed variability in perceptions of ecological restoration goals between rural and urban areas, with rural communities viewing restoration primarily as a means to protect property and human life.

Public Support: What are public perceptions of forest and watershed restoration practices?

Summarize how addressing this topic is time-sensitive and urgent for guiding post-fire restoration and recovery.

Member 1	Member 2	Member 3
Understanding public support or perceptions of post-fire R&R practices is time-sensitive because implementing post-fire management has to be done promptly to maximize impacts. If there is a lack of public support, or public backlash, around a management approach, this can prevent it from being implemented. Thus, it is advised to understand public support and start public engagement, before the fire occurs, in order to have greater success post-fire. In addition to this temporal dynamic, engaging only after a fire occurs brings additional complications, since communities are dealing with the effects of fires and in the case of fires on public lands, may have heightened distrust.	Public perceptions of forest management in the western U.S. have already been explored across many studies for several decades. Thus, the expansion of this topic may be of less importance in guiding post-fire restoration and recovery compared to other suggested topical areas. There is room for better understanding, however, in perceptions of specifically post-fire treatments; perceptions of treatments among understudied populations or in overlooked regions; and how managers are affected by their perceptions of public opinions (building upon Steelman and McCaffrey 2011). Additionally, Edgeley (2023) argues for more qualitative approaches to better understand public reasoning behind opinions; exploration of perceptions of treatments in wilderness or other areas with little intervention to date; understanding factors that drive public opinions; exploring manager perspectives of monitoring; and delving into prioritization and implementation processes. Advancing knowledge in these areas can contribute to enhanced understandings of how to facilitate desired post-fire treatments specifically.	Public perception of restoration is influencing legislation, policies, and ordinances that directly affect the restoration activities allowed in a watershed. Conducting research on the relationship between public perception and identifying where to focus efforts and outreach will better inform public land managers and policymakers in their actions before, during, and after wildfire events.

Public Support: What are public perceptions of forest and watershed restoration practices?

Suggested revisions, Member 1: *Combine with other topics*
Potentially. Stakeholder engagement is considered a spectrum, and this topic is about understanding public support in order to inform the public, which is at one end of the spectrum because it does not allow public participation but simply provides information to increase understanding. In the middle of the stakeholder engagement spectrum would be consulting and involving the public and collaborating would be at the other end of the spectrum. Thus, this issue could be linked to the topic of community engagement, where the public is allowed to voice concerns and inform management decisions. I am not sure we want to lose these separate levels of engagement but wanted to point out that these topics could be linked together as different levels of engagement.
Suggested revisions, Member 2: *NONE*
Suggested revisions, Member 3: *NONE*

Equity: How can we design post-fire recovery programs and processes to be equitable, inclusive, and attentive to social justice issues?

Summarize how addressing this topic would have a significant impact on guiding post-fire restoration and recovery.

Member 1	Member 2
There is a need to understand how people and communities are being differentially affected by wildfire and wildfire recovery to shape solutions (policies, governance structures, communication strategies, etc.) that meet their needs. There is, however, is limited research on post-fire recovery that pays attention to issues of equity, inclusivity, and justice. Meta-analyses of existing literature illustrate that thus far wildfire research has largely focused on the pre- or during fire time periods; limited demographic analyses (e.g., focused on income and race); wildfire exposure rather than other components of vulnerability such as sensitivity and adaptive capacity; and wildfire impacts rather than recovery solutions. Moving forward with recovery without consideration of differential vulnerability and the inequitable circumstances that have created different levels of vulnerability will perpetuate or exacerbate existing injustices. An approach to wildfire recovery that examines who is included or excluded in decision-making and centers equity “rather than landscape outcomes” has the potential to radically shift solutions implemented (Lambrou 2023). (Thomas et al., 2022).	Communities that encounter environmental crisis come in many different shapes and sizes. Some contain what literature once referred to as "informal economies" or "parallel economies". When disaster occurs, the parts of economies that are "formal differently" in these communities are often forced to transform to align the dominant bureaucratic and economic sphere of influence (i.e. FEMA and other administrative assistance). While those processes have great transformational power (i.e. economic development potential), they also run the risk of de-incentivizing economic behavior and economic values that are essential to sustaining traditional practices. Consequently, a community identify can change irrevocably if the dominant economic sphere intervenes without understanding the broad implications of their interventions, especially when the urgency to act is a factor. More studies are needed to understand value and economic choices that are contained by Recently, the term "pluriverse" is being used to explain the intersection of competing but co-existing realities.

Equity: How can we design post-fire recovery programs and processes to be equitable, inclusive, and attentive to social justice issues?

Summarize how addressing this topic is time-sensitive and urgent for guiding post-fire restoration and recovery.

Member 1	Member 2
Focusing on gaining a better understanding of equity in wildfire recovery is urgently needed because of the growth of wildfire impacts through the increasing size and frequency of fire events affecting residents. While some studies have documented that many less vulnerable populations have the most exposure to wildfire risk (i.e., wealthier households purchase homes in attractive WUI areas) (Wigtil et al. 2016; Davies et al. 2018), this pattern is changing as more people are priced out of more urban housing markets and other drivers are shifting how vulnerable people and communities are impacted by wildfire (Thomas et al. 2022). Thus, more people are being affected by wildfire to a greater degree, who is being affected by wildfire is changing, and there is limited understanding of how post-fire recovery processes can address equity issues that caused vulnerability in the first place and also lead to improved resilience. Gaining a better understanding of planning post-fire recovery with equity, inclusivity, and justice in mind is urgently needed to inform successful and equitable recovery solutions as the impact of wildfire on diverse populations grows.	The effects of compensation on post-Wildfire communities is immediate and has long-lasting implications for the health and identity of communities. Once systems of value are introduced into the market, it becomes very difficult for non-market values to compete or to survive. In effect, traditions and practices that have existed for generations may be compromised by short term injections of capital. In many cases, the effect is discreet and rarely discussed except on occasions when traditions that have been taken for granted lose their tie to individuals or to collective influence. Once bureaucratic systems are initiated, such as taxation, non-market systems become increasingly illegible, and with it comes the ability for incorporated systems (those who are able to navigate the dominant bureaucracy to a high degree) to relate to those more discreet, non-market systems. These forms of alienation push systems within a "pluriversal economy" further apart. The effect is immediate and tangible, including the effect this has on young populations who must then choose between systems rather than existing in places where such worlds and worldviews once coexisted.

Suggested revisions, Member 1: *Combine with other topics*

Yes - community resilience and recovery

Suggested revisions, Member 2: *Topic Phrasing*

I would change the title to say: "Equity: How can we design post-fire recovery programs and processes to be equitable, inclusive, and attentive to a more resilient and just pluralistic society?"

Traditional Knowledge: Where can Indigenous practices and knowledge inform restoration and recovery?

Summarize how addressing this topic would have a significant impact on guiding post-fire restoration and recovery.

Member 1	Member 2
Indigenous knowledge should inform rehabilitation of forested lands burned by high-intensity wildfires. A primary contributing factor to the rise in high-intensity fires has been the disruption of historical fire regimes and Indigenous fire stewardship. Since colonization, due to genocide, forced relocation, criminalization, and delegitimization of traditional lifeways, Indigenous people have been prohibited from practicing Indigenous fire stewardship. Landscapes burned by high-intensity fire present serious recovery challenges to land managers, but they also present opportunities for revisiting management and seeking ways to restore Indigenous rights and practices. For this to happen, it will be necessary to give Indigenous people the space and freedom they need to implement IK on their private, trust, and ancestral lands, on their terms and through co-management. However, the importance of restoring IK should not be used as an excuse for cultural and knowledge appropriation; IK cannot be extracted from Indigenous people. Rather, they must be involved in co-stewardship and management if there is to be integration of Indigenous knowledge with Western science for land management.	Indigenous peoples have been data gatherers about ecosystems and landscapes since time immemorial (Adams, 2024). Utilizing this long-standing knowledge would have a significant impact in guiding post-fire restoration and recovery. Where this knowledge can be utilized is dependent upon the specific places where these knowledges are held and specific purposes that knowledge holders have to engage with this data. Adams (2024) highlights the growing interest and recognition of traditional fire knowledge and explains the need for Indigenous fire data sovereignty principles to be used by academic researchers and fire managers when engaging in traditional fire knowledge research. Adams (2024) also provides beginning steps for academics to engage in Indigenous Fire Data Sovereignty, particularly steps to be led by Indigenous communities in designing fire research. Traditional fire knowledge can provide a significant impact in guiding post-fire restoration and recovering but is dependent on where this knowledge is held, and how Indigenous communities want to apply this knowledge

Traditional Knowledge: Where can Indigenous practices and knowledge inform restoration and recovery?

Summarize how addressing this topic is time-sensitive and urgent for guiding post-fire restoration and recovery.

Member 1	Member 2
Pre-colonization and settlement, post-fire environments were expansive landscapes shaped by the knowledge, cultivation practices, and fire stewardship of Indigenous people and were rarely in need of "rehabilitation." For millennia, Indigenous fire stewardship influenced the evolutionary course of plant species and plant communities through (in part) the regular application of fire. These practices derived from cultural fire regimes that influenced and diversified the frequency, seasonality, extent, locality, intensity, and resultant severities of fires. When the cultural influence of Indigenous people was removed from the land, so too were the beneficial effects of fire. Evidence suggests that colonial land management over the last century, specifically the taking of land from Indigenous people, criminalization of Indigenous fire stewardship, and wide-scale fire suppression together have resulted in wildfire intensities that are unique over more than 900 years of record. Considering the magnitude of disruption leveled upon fire adapted ecosystems through the forced removal of Indigenous people, the reintroduction of IK to the land could not be more urgent.	This topic is time sensitive and urgent due to the growing disproportionate impacts of climate change impacts on Indigenous communities, the large extent of lands managed by Indigenous peoples and nations, and the need for additional capacity by many Indigenous communities and nations to develop fire management strategies and utilize Indigenous knowledges. Adams (2024) discusses the call for development and application of scientific research for post-fire restoration and recovery and how Indigenous Fire Data Sovereignty Principles and CARE principles can be utilized through continuous consultation with Indigenous communities so that community members, leaders, and knowledge keepers can be informed and inform post-fire management strategies.

Suggested revisions, Member 1: *NONE*

Suggested revisions, Member 2: *Topic Research Questions*

How can Indigenous fire stewardship be supported to inform restoration and recovery?

Economic Valuation and Pluriversal Economies: How does one produce economic valuation within pluriversal economies? How do environmental and economic crises make a pluriversal economy legible?

Summarize how addressing this topic would have a significant impact on guiding post-fire restoration and recovery.

Member 1	Member 2
Communities that encounter environmental crisis come in many different shapes and sizes. Some contain what literature once referred to as "informal economies" or "parallel economies". When disaster occurs, the parts of economies that are "formal differently" in these communities are often forced to transform to align the dominant bureaucratic and economic sphere of influence (i.e. FEMA and other administrative assistance). While those processes have great transformational power (i.e. economic development potential), they also run the risk of de-incentivizing economic behavior and economic values that are essential to sustaining traditional practices. Consequently, a community identify can change irrevocably if the dominant economic sphere intervenes without understanding the broad implications of their interventions, especially when the urgency to act is a factor. More studies are needed to understand value and economic choices that are contained by Recently, the term "pluriverse" is being used to explain the intersection of competing but co-existing realities.	This topic is of great significance to post-fire recovery because it is critical that we get better at honoring--and literally valuing for purposes of compensatory compensation-- a diversity of economic ways of being in rural landscapes in the Intermountain West. FEMA is currently strugglingly to do this in a just and efficient way, and the cascading effects of this failure will be felt for generations in rural communities in the absence of better valuation strategies post-fire.

Economic Valuation and Pluriversal Economies: How does one produce economic valuation within pluriversal economies? How do environmental and economic crises make a pluriversal economy legible?

Summarize how addressing this topic is time-sensitive and urgent for guiding post-fire restoration and recovery.

Member 1	Member 2
The effects of compensation on post-Wildfire communities are immediate and have long-lasting implications for the health and identity of communities. Once systems of value are introduced into the market, it becomes very difficult for non-market values to compete or to survive. In effect, traditions and practices that have existed for generations may be compromised by short term injections of capital. In many cases, the effect is discreet and rarely discussed except on occasions when traditions that have been taken for granted lose their tie to individuals or to collective influence. Once bureaucratic systems are initiated, such as taxation, non-market systems become increasingly illegible, and with it comes the ability for incorporated systems (those who are able to navigate the dominant bureaucracy to a high degree) to relate to those more discreet, non-market systems. These forms of alienation push systems within a "pluriversal economy" further apart. The effect is immediate and tangible, including the effect this has on young populations who must then choose between systems rather than existing in places where such worlds and worldviews once coexisted.	Global climate change is predicted to have an ever-increasing impact on forested watersheds in the Intermountain West. Rural, headwater dependent communities will be particularly hard hit, and it is urgent and essential to assist emergency management agencies like FEMA in becoming better equipped to understand the complexity of these communities and their economies in order to address climate events and build adaptive capacities. There are some encouraging signs in the case of the Hermits Peak Calf Canyon fire, where FEMA has been directed by Congress to infuse billions into the community and recognizes “subsistence work” as worthy of compensation (88 Fed. Reg. 59730). By making more diverse types of relationship with forests visible and worthy of compensation for losses owed, communities are more likely to be provided the support they need to adapt their rapidly changing world while also maintaining their values, practices and identities (Walker and Salt 2012).

Suggested revisions, Member 1: *NONE*

Suggested revisions, Member 2: *Topic Phrasing, Topic Research Questions*

Pluriverse = a world with multiple ways of being and doing that emphasizes the dynamic interconnection of humans and other living beings (Escobar 2020). Rural communities have multiple ways of being and doing in relationship with the forested landscapes in which they live. When wildfires move through these communities, as they are with increasing intensity and impact throughout the American West, the traditional formulas for “disaster assistance” used by the Federal Emergency Management Agency (FEMA) struggle to recognize the economic value of these relationships.

How do we move past emergency management and compensation and toward adaptive capacity building for place-based communities?

National Coordination: What organizational and financial structures are necessary to better integrate the national response to fires and post-wildfire impacts across agencies and scales?

Summarize how addressing this topic would have a significant impact on guiding post-fire restoration and recovery.

Member 1	Member 2
The interagency coordination challenges in wildfire response and postfire recovery are well documented in academic, practitioner, and policymaking spaces—challenges that also persist in other disaster response contexts (see, e.g., the GAO, 2022). Given this, research focusing on solutions to the constraints on interagency coordination stemming from what Davis et al., (2022) termed “parallel play”) in wildfire response and recovery would represent a significant step towards guiding a paradigm shift in postfire restoration and recovery. In addition to focusing on designing integrative mechanisms for organizational and financial structures, research on solutions should also address the social and cultural barriers (e.g., mission misalignment across agencies at different scales) that confound better coordination (Fleming et al., 2015). If a functional integration of organizational and institutional structures—one that preserves agency autonomy— is achieved, the impact would reach beyond wildland fire and postfire to other disaster recovery systems.	The Congressionally-chartered Wildfire Management and Mitigation Commission recognized the inadequacy of current organizational and financial structures to cope with post-fire impacts and argued for a “whole of society” approach that is fully inclusive of non-federal entities. Their report details the ways in which federal agency programs and funding mechanisms fail to address the cascading impacts triggered by catastrophic wildfire: losses that range from critical infrastructure destruction, to and financial instability at the individual and community level, to mental health declines, and increasing housing costs. While the Commission devotes an entire chapter to “recovering for resilience” and offers 24 recommendations, most are general in nature and need further refinement to be actionable. Research that explores and documents the real-life solutions patched together by affected communities could be extremely important to devise state and national policy, with a focus on the interagency, multi-partner and collaborative organizational systems and ways of combining and using various funding streams.

National Coordination: What organizational and financial structures are necessary to better integrate the national response to fires and post-wildfire impacts across agencies and scales?

Summarize how addressing this topic is time-sensitive and urgent for guiding post-fire restoration and recovery.

Member 1	Member 2
Given the current interest in (and support for) integrating the national response (as evidenced by The Wildland Fire Mitigation and Management Commission's 2023 report which identified the need for developing "Urgent New Approaches" to overcome coordination barriers in wildfire response and postfire recovery (see recommendation #60)), there seems to be window of opportunity for research to inform policy on this topic. For that reason, I would say this is a time-sensitive topic.	As wildfires and post-fire disasters intensify, the time sensitivity and urgency for research on the topic of organizational and financial systems increases. We've seen in New Mexico how different communities have handled the post-fire transition and recovery period, with Las Vegas and Ruidoso providing stark differences in their capacity and approach and offering different lessons learned. Taken on the scale of the West, with new disasters unfolding nearly year-round, the time-sensitivity is increasing.

Suggested revisions, Member 1: *Topic Research Questions, Combine with other topics*

I would suggest including "institutional" in the research question, which broadens the question a bit, but in my mind allows for more comprehensive research agenda for this topic.

What organizational, institutional, and financial structures are necessary to better integrate the national response to fires and post-wildfire impacts across agencies and scales? Anticipatory & Collaborative Governance: What types of anticipatory and collaborative governance approaches can be developed to better prepare for wildfire recovery?

Suggested revisions, Member 2: *NONE*

Anticipatory & Collaborative Governance: What types of anticipatory and collaborative governance approaches can be developed to better prepare for wildfire recovery?

Summarize how addressing this topic would have a significant impact on guiding post-fire restoration and recovery.

Member 1	Member 2
As wildfires have become more common and more widespread in the western US, there has been a surge in the use of polycentric and adaptive governance approaches to deal with the multi-jurisdictional challenges that emerge when fires burn across borders. This approach to management is in many ways significantly different to the way fire management has been addressed over the past century. Polycentric governance blends top-down and bottom-up approaches to flexibly tailor responses to each unique location and their attendant issues. However, how best to use this approach, and when it should or should not be applied is still unclear. More research into the conditions necessary, resources needed, and challenges faced by groups attempting polycentric governance are needed to best support communities across the West in adapting to changing wildfire regimes.	Wildfire does not respect jurisdictional boundaries, and, while anticipated, actual wildfire events can never fully be foreseen in any season. Moving past "emergency" response to more anticipatory governance approaches and are sufficiently aggressive in terms of climate adaptation to wildfire requires a change paradigm. Challenges are both acute (a fire event) and chronic (drought, bark beetle infestation, other factors increasing vulnerabilities and reducing resilience). The emerging field of anticipatory governance (Muiderman et al. 2020) offers a way for thinking about how to govern in the present to adapt to or shape uncertain futures. This builds on the more familiar literature of adaptive governance (Sharma-Wallace et al 2018). It's relative "novelty lies in seeking to steer away from short-term decision-making to longer-term policy visioning in ways that can anticipate change and help realize more sustainable futures. Such perspectives also highlight the role played in anticipatory processes by local communities and a diverse array of stakeholders (Boyd et al., 2015; Serrao-Neumann et al., 2013; Tschakert & Dietrich, 2010)."

Anticipatory & Collaborative Governance: What types of anticipatory and collaborative governance approaches can be developed to better prepare for wildfire recovery?

Summarize how addressing this topic is time-sensitive and urgent for guiding post-fire restoration and recovery.

Member 1	Member 2
Much research on wildfire response and recovery is focused on the biophysical realm. While understanding how physical systems react and respond to changing wildfire regimes is of utmost importance, so too is our understanding of how best to organize and support our institutional responses to such changes. With billions of dollars being poured into forest management and wildfire response, we need more efficient and flexible ways to allow communities affected by wildfire to access these funds to coordinate adaptive responses based on individual location needs and issues. This is particularly important as policies and regulations are notoriously difficult to change, often requiring disasters to create "windows of opportunity" where new ideas and practices are tested and formalized. Without the ability to integrate top-down knowledge and resources with bottom-up insights and action, truly adaptive responses to fire, that help prevent or mitigate negative outcomes, will be hampered.	Studying approaches identified in both adaptive and anticipatory governance for climate change broadly and postfire recovery specifically is urgent for two reasons. One is the nature of the challenge. A new study published in Nature Ecology & Evolution this year shows that the number and intensity of the most extreme wildfires on Earth have doubled over the past two decades (Cunningham et al 2024). Yet our policies and practices are struggling to keep up with this new reality. So while the challenge is increasing, our response is generally not keeping pace. Second, there are a number of societal responses that happing right now in U.S. as a result of both the Infrastructure Bill and the Inflation Reduction Act. While these are "one off" measures, they do provide unprecedented investments in community-level climate resilience and resulting opportunities for learning across jurisdictions and scales. Studying the efficacy of various measures is critical to future, more ongoing investments.

Suggested revisions, Member 1: *NONE*

Suggested revisions, Member 2: *Topic Research Questions*

How can we make governance more anticipatory? Are current governance approaches ambitious enough?

Planning: How can pre-fire planning processes be used to prepare for and fund post-fire recovery?

Summarize how addressing this topic would have a significant impact on guiding post-fire restoration and recovery.

Member 1	Member 2
A lack of formal planning methods creates challenges in pre- and post-wildfire planning. In some areas, past disasters improve future planning, as seen in Colorado, where earlier fires shaped post-wildfire playbooks for rapid response after the East Troublesome and Cameron Peak Fires (Colorado Silver Jackets, 2021). A key barrier to preparedness is failing to learn from past experiences (Kartez & Lindell, 1987), which was evident in New Mexico's response to the Hermit's Peak-Calf Canyon Wildfire (Buettner & Schultz, 2024). Emergency plans often overlook extraordinary events or fail to integrate post-wildfire readiness into all-hazard planning (Headwaters Economics, 2018). Additionally, "paper plans" don't scale information to decision-making needs. Recovery frameworks, like FEMA's National Planning Frameworks, vary by state and don't always meet community needs (BALN, 2018). Practitioners increasingly look to CWPPs and collaborative readiness, but research remains limited (Coconino County, 2024; Evans, 2017; Huayhuaca et al., 2023). More research is needed to tailor disaster planning to post-fire contexts and standardize approaches.	Post-fire recovery is often costly and requires procuring funding from several sources. A variety of funding mechanisms are available and partnering with a watershed group or non-governmental organization (NGO) may help to facilitate the process.1 Most grants take time to apply for and receive, so establishing pre-fire Local Recovery Group & Regional Recovery Group contacts is necessary. The NRCS Emergency Watershed Protection (EWP) program provides technical and financial assistance following natural disasters in order to prevent further damage from flooding, runoff and erosion (www.nrcs.usda.gov). The New Mexico Department of Homeland Security and Emergency Management (NMDHSEM) provides grants to local governments, tribal entities and state agencies in Presidentially declared disaster areas that reduce the overall hazard to communities (www.dhsem.nm.gov). The US Army Corps of Engineers (USACE) has a suite of programs to assist communities to reduce flood risk after a wildfire, restore riparian ecosystems, and provide technical analyses related to water issues (www.spa.usace.army.mil).2

Planning: How can pre-fire planning processes be used to prepare for and fund post-fire recovery?

Summarize how addressing this topic is time-sensitive and urgent for guiding post-fire restoration and recovery.

Member 1	Member 2
Advancing knowledge on pre-fire planning for post-fire recovery is crucial as wildfires grow in frequency and intensity. Events like the Cerro Grande and Las Conchas Fires left New Mexico ill-prepared for more recent disasters, such as the Hermit's Peak-Calf Canyon Wildfire (Buettner & Schultz, 2024). This knowledge gap hinders recovery, despite existing disaster plans. Fires are becoming more severe, rendering many local plans inadequate for extreme events. While frameworks like the CWPP offer the potential for post-wildfire planning, they lack sufficient research for effective implementation. Collaborative frameworks that provide timely, cross-jurisdictional recovery information are essential for improved resource management and funding allocation. Post-fire governance varies across states, necessitating adaptable frameworks (Buettner & Schultz, 2024). Expanding research on strategies to manage large wildfires and foster resilience is critical (Headwaters Economics, 2018). Pre-fire plans enable communities to prioritize mitigation, reinforce infrastructure, and reduce wildfire risks to lessen post-fire impacts.	Pre-fire planning process to prepare and fund post-fire recovery is time-sensitive because of several reasons. First, on NM state and private lands jurisdiction is generally not clear, inhibiting efficient funding for post-fire recovery. No post-fire specific funding is allocated, instead most post-fire recovery support comes from other funding sources where post-fire recovery has been added to an existing program. There is no single agency that bears responsibility across multiple land ownerships, disciplines, resources, etc. that are directly impacted by post-fire conditions. In addition, multiple agencies, government levels are impacted but each has only partial responsibility for on the ground post-fire recovery.

Suggested revisions: *NONE*

Workforce Development: How do we develop and maintain a restoration workforce?

Summarize how addressing this topic would have a significant impact on guiding post-fire restoration and recovery.

Member 1	Member 2
There is a limited workforce available to meet all of the post-fire restoration needs. In many cases, the same workforce would be the ones needed for a variety of activities. Wildland fire fighters make up a large portion of the restoration workforce, but their time is divided amongst suppression, prescribed fire operations, and other projects supporting fuels reduction and forest restoration. Prescribed fire and reforestation in the Southwest share many of the same operational windows driven by weather. There is a need both to leverage the existing workforce of wildland firefighters for other forestry projects and to also create dedicated workforces for reforestation and prescribed fire. Without a workforce, the question of which management actions to pursue in post-fire environments is moot. Other considerations include barriers to engaging with local businesses and contractors to perform post-fire restoration work. Are local resources and businesses available to engage in post-fire recovery work but are unable to navigate federal procurement systems?	Management plans mean nothing until they are implemented. Until something actually does something, things are not done (me, pers. comm.). Sporadic efforts limited by the availability of a work force (volunteer weekends, etc.) are a difficult way to implement management. Development of a dependable workforce can be the difference between successful management and failure. Speaking anecdotally, it's been my experience that a dedicated, available workforce is one of the most valuable tools a manager can have. Youth conservation corps have proven useful in many land management efforts, although results can be mixed. In my experience, a good seasonal workforce can be created and deployed to tremendous results. I believe it's important to create a sense of community and belonging in a shared goal can help create a stable and dependable workforce, with the added benefit of growing a larger community of folks invested in the future of our natural world.

Workforce Development: How do we develop and maintain a restoration workforce?

Summarize how addressing this topic is time-sensitive and urgent for guiding post-fire restoration and recovery.

Member 1	Member 2
Without a workforce, post-fire restoration and recovery will be at best limited and at worst, impossible. This topic is time sensitive for several reasons, (1) because reforestation efforts become more difficult as other non-conifer species take hold, necessitating more site prep and intervention to make sites conducive to seedling success, (2) the occurrence of fires causing large treeless patches is increasing, (3) post-fire disturbances like wind events, drought, and re-burn all impact the potential trajectories of large treeless patches (4) There is unprecedented federal funding available for forest restoration and post-fire recovery efforts thanks to the IRA, BIL, and commitments from the federal government to foot the bill for recovery efforts for USFS caused fires (HPCC). If various stakeholders don't take advantage of these funding opportunities now, prospects for funding from federal sources may be limited in the future. Waiting to solve the workforce problem will only make solving the post-fire recovery problem harder.	Having a workforce large enough to begin to address the issues surrounding burned landscapes is becoming more important and harder to achieve with each fire season. Developing strategies to create and maintain these workforces would ideally be self-fulfilling as veteran workers recruit younger workers and expand the workforce. Federal and state agencies are not up to the task of implementation without additional outside workforces. Seasonal youth groups/conservation corps can be good but are often focused on a variety of tasks. Creation of a fire recovery work force would likely improve the ability to address the increasing need.

Suggested revisions, Member 1: *NONE*

Suggested revisions, Member 2: *Combine with other topics*

Not combined with but related to this question "Community Engagement: How can we better engage communities in restoration and recovery efforts and what are the barriers?" There are economic and workforce development opportunities for local communities and those affected by wildfires to engage in post-fire recovery.