Wildfire Resilience Workshop Series
Summary of Workshop 4: Post-Fire Restoration and Resilience

On April 27-28, 2022, the Aspen Institute Energy & Environment Program and The Nature Conservancy convened a hybrid workshop (with both virtual and in-person participants in Boulder, Colorado) — the fourth in a series on U.S. wildfire resilience. Building off of past roundtable conversations around the passage of the bipartisan infrastructure law and its unprecedented levels of funding for wildfire resilience work, this convening brought together state, Tribal, federal, NGO, and other experts to create a shared understanding of the scale, distribution, and impacts of post-fire reforestation needs; explore what is being done to address them; and develop recommendations to address gaps and barriers. This summary captures key points from presentations provided during the workshop, along with key topics of discussion.

Scope & Scale of Post-Fire Reforestation Need in Western Forests

Increasing the resilience of forests to wildfire involves mitigating risk through forest management pre-fire, but also reforestation and restoration work in forests and watersheds after fire occurs. This post-fire management is essential to make sure the landscape can regenerate, be healthier, and better withstand the next fires. Reforestation encompasses a suite of activities, from selection of genetically appropriate species and seeds, stocktype, site preparation, outplanting techniques and windows, to planning for post-planting monitoring. Reforestation ensures that forests can continue to provide clean water and carbon storage, among a host of other benefits. Indeed, restoring tree cover can be a vital natural climate solution.

The need for reforestation is substantial and growing. Using a simplistic method – identifying areas that are (1) ecologically appropriate for greater than 25% tree cover, (2) not currently forest, and (3) not devoted to urban or agricultural uses — analyses suggest there are 53 million hectares of potential reforestation opportunities across the lower 48 states[1]. Not all of those areas are actually appropriate for restoring tree cover, however, and a more refined approach to identifying opportunity areas might include looking at: (1) areas already in natural land use (e.g., shrub cover, protected areas) and post-fire locations; (2) areas of human uses such as agricultural and pasture lands; and (3) areas of human use where tree cover would offer high

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[1] Based on Cook-Patton et al. (2020) Lower cost and more feasible options to restore forest cover in the contiguous United States for climate mitigation. One Earth 3, 739–752.

co-benefits (e.g., frequently flooded landscapes, areas near streams, urban open space, species migration pathways). Nationally, there are big opportunities in pasture lands (that historically supported forests) and post-burn areas. The overall opportunity is greatest in Eastern states (where forests grow faster), but the federal land opportunities and post-fire opportunities are mostly in the West.

Climate change is increasing wildfire activity in the West. The area burned has quadrupled in the last two decades. Fires have become more frequent, larger, and more severe, with both more area and a higher proportion of area burning at high severity.

These trends are evident on U.S. Forest Service (National Forest System, NFS) lands. From 1950 through 1980, timber harvest revenues funded reforestation needs on USFS lands. Around 1999-2000, however, wildfire began causing more reforestation needs and have since become the main causal agent (accounting for about 80% of the reforestation need). The USFS has identified over 5 million acres of potential reforestation needs due to fires, and that number is growing every year. About 2 million of those acres have been assessed on the ground so far and determined to require reforestation. Other areas have observed natural regeneration.

Post-Fire Landscapes & Climate Change

Climate change is both a driver of reforestation needs and a key consideration in how to design reforestation efforts. For example, hotter and drier temperatures have influenced natural conifer regeneration in the West after fires. Since 2000, there has also been an increase in fires without subsequent tree regeneration in the burn scars, particularly in dry forest types such as ponderosa pine. And in some locations, grasses and shrubs have replaced areas where there were once mature ponderosa and mixed conifer forests. This is due to i) hotter and drier temperatures that make it harder for seedlings to establish, and ii) increase in the size of high-severity patches in which there are no surviving seed-bearing trees.

Changing climate conditions also play a key role in influencing reforestation. The probability of post-fire recruitment declines as one moves from wetter to drier sites. Climatic changes are also yielding fewer and fewer years with a climate suitable for high levels of natural tree regeneration, as analyses suggest that regeneration is hindered if even one of the five years post-fire is abnormally hot and dry.

Significant increases in reforestation needs are expected in many Western states, due both to increases in area burned and other kinds of disturbances such as insect outbreaks. The significantly changing trends in natural regeneration seen in the Southwest over the past 20 years (with limited regeneration in drier places) are expected to move northward in the future. Many parts of the Southwest and other drier parts of the West may need to expect and plan for limited regeneration following high-severity fires, while some higher-elevation forest types may exhibit abundant natural regeneration through at least mid-century. There are many scientists producing models to help guide where to prioritize regeneration on the landscape.

In projections, fire severity has an even more significant impact on regeneration than changing climate conditions in certain areas, suggesting that efforts to reduce fire severity in those areas could have a big impact on post-fire regeneration. The outcomes vary by forest type, though, as ponderosa pine ecosystems, for instance, have much higher recruitment after low-severity fire than after high-severity fire. Low severity fire allows some trees to survive fire and often requires no reforestation. Moderate and high severity often kill the trees, eliminating the seed source. If the patches burned at high severity are large enough, and the average distance a ponderosa pine seed travels is 50 m from an adult seed-bearing tree, then natural regeneration may be limited due to lack of seed sources. Subalpine fir also has a low probability of recruitment in a high-severity scenario; being shade tolerant, it can take a long time to regenerate after a fire, but with climatic changes, it may not have the multiple decades to recover. Forest types such as lodgepine pine, on the other hand, are more adapted to high-severity fire regimes and are expected to have higher rates of natural recovery.

Looking at treeless patches and the climate suitability of individual species across the landscape, it is possible to identify areas where it might be more suitable to plant particular species for a future climate and areas where it might not be.

The Resist-Accept-Direct (RAD) framework provides a key way of thinking about the three choices available when faced with ecological transformation (e.g., after big fires). The options are to resist changes on the landscape (e.g., reforest post-fire with the same species that were there pre-fire), accept the changes on the landscape, or direct changes in response to the changing conditions.

With respect to the choice of species, reforestation that is responsive to climatic changes must also start involving the relocation of species. This could include moving low-elevation seeds to higher elevations, or moving seeds along latitudinal gradients from southern locations to northern locations[2]. Other experts suggest that, in fire prone areas adjacent to communities, it may be worth exploring approaches to replant species (e.g., aspen) that do not carry fire like conifers do.

There are concerns in the forest industry, however, about the impact of assisted migration on species composition, especially as mills are specialized for specific wood products. Likewise, in some regions, there are cultural considerations to consider. In the Jemez Mountains in New Mexico, for instance, there are efforts in impacted areas to re-establish culturally important trees in mixed-conifer zones to help sustain connections between Puebloan communities and the landscape.

Researchers are thinking not only about species, but also about densities in the context of climate change and wildfire trends. It may be important to think about planting lower densities

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[2] Note: The USFS has authority to move genotypes within a species' range and to move species within range limits (e.g., northward migration), but the agency does not have authority to move species from far outside their range into new areas.

to build resilience into the structure of future forests. Landscapes being replanted might now burn again in another 30 years, not 100, and it is important to plant in ways that minimize the risk to the replanting investment. Lower-density, more heterogeneous landscapes might allow for some patches to survive future fire.

Monitoring will be vital and must be planned thoughtfully. Reforestation efforts might look right early on but be maladapted to a changing climate. An investment in monitoring is needed now to inform landscape work years and decades into the future.

New Laws, Policies, & Funding

Given the current rates of reforestation, it would take decades to address the existing need, without taking into account future disturbances; a shortfall which has sparked new laws and funding for the USFS. The REPLANT Act, which was part of the 2021 Bipartisan Infrastructure Law, is the most significant piece of legislation since 1980 for reforestation on national forests. Among its key provisions, the Act directs the agency to develop a new strategy and process to prioritize disturbance-caused reforestation needs, sets a 10-year target to address the reforestation backlog on USFS lands, and adds additional reporting requirements. Most importantly, the REPLANT Act raises the $30 million cap on the reforestation trust fund, potentially enabling upwards of $150 million per year in funding (depending on the tariffs on imported wood products). REPLANT's resources will enable the USFS to start acting and expanding its capacity and infrastructure, and will facilitate broader engagement with partners as well to increase non-federal investment in reforestation. Although it will take the agency time to scale up, REPLANT has the potential to be monumentally impactful.

There are also many other relevant provisions in the infrastructure law beyond REPLANT, several of which provide additional funding for post-fire recovery. For example, provisions related to burned area recovery (BAER) provide more opportunity, time, and resources for the USFS to focus on post-fire management practices such as slope stabilization that can be important alongside reforestation efforts. There is also funding for ecosystem restoration, Good Neighbor Agreements, small-diameter material coming off lands, and much more, comprising a whole universe of funding that can touch different components of a cohesive strategy. Many of the provisions have their own restrictions, guidelines, and reporting requirements, and the agency is figuring out how to integrate all the different pieces across the continuum of fire-related work on the landscape, responsibilities for which have historically fallen in discrete areas of the agency. Outside the USDA, departments like the Department of Interior and the Federal Emergency Management Agency have relevant funding streams. The immediate priority, however, is to get the 10-year strategy funds out to priority landscapes. The sheer scale of funding, short timeframes, and agency capacity limit how quickly the agency can make other allocations.

In addition to new legislation, the Biden Administration has supported existing work on forest lands, including in executive orders. Executive Order 14008 on the climate crisis directs the U.S. Department of Agriculture (USDA) to develop a climate adaptation resilience plan (completed),

including ramping up climate-informed reforestation. The new executive order on strengthening the nation's forests, communities, and local economies includes two areas related to reforestation, one directing the USFS to develop specific reforestation targets by 2030 and to strengthen reforestation partnerships, and the other directing development (with partners) of a climate-informed plan to ensure appropriate seed and nursery capacity.

USFS Reforestation Strategy

The provisions in the bipartisan infrastructure law and the executive orders give the USFS a mandate and funding to tackle reforestation on NFS lands. To operationalize its mandate, the agency is working to develop a reforestation strategy for national forests, to establish a vision for the future that considers the changing climate and builds a flexible framework for current and future reforestation needs. It is not just a tree-planting strategy; the goal is resilient future forests, and reforestation is a tool to help achieve that. The strategy is built on three guiding principles: 1) lead with science and technology, 2) strengthen internal resources and capacity, and 3) partner and collaborate to accelerate and amplify success.

The strategy is structured around six goals, each with specific objectives, enumerated below:

- *Understand current and future reforestation needs:* The agency has been good at identifying post-harvest reforestation needs and is starting to get better at identifying fire-caused reforestation needs, but there is more work to be done in this area.

- *Develop a set of shared reforestation priorities across the agency and with partners:* Prioritization of needs on the landscape historically has involved factors such as cost, access, and Forest Plan stocking requirements (on National Forest System lands), but there is an opportunity now to think more broadly about what to prioritize (e.g., places that may be farther from a road but are important for a municipal watershed). REPLANT gave the agency some priorities, but there will be discussions and prioritization decisions at the regional, forest, and other levels to address some of the nuances involved in reforestation.

- *Expand reforestation workforce capacity, seed production, nursery capacity, and reforestation infrastructure:* It will be essential to invest in the core parts of these processes — where the rubber hits the road in reforestation — in order to be successful.

- *Ensure today's seedlings grow into tomorrow's resilient forests:* Reforestation is more than just getting trees in the ground; landscape-scale thinking is needed to accurately site reforestation projects, strategically protect seed trees, and to build resilience into project design.

- *Nurture forests to enhance future resilience:* Building on the prior goal, there needs to be explicit consideration around issues such as density and species selection in reforestation project development in order to enhance the long-term resilience of forests.

- *Cultivate a shared story:* It is important to communicate the value and benefits of reforestation and its goals, to strengthen internal and external support for this work. At all levels, including policymakers and the broader community, there is a need for clear, concise messaging to make sure people understand why the research and the range of implementation activities related to reforestation are needed.

This national strategy is expected to be released publicly soon, after which the regions will be developing 10-year implementation plans (starting in the next fiscal year) to further guide more granular action. In FY22 staff will be focused on planning and prioritization, and there will be some increase in on-the-ground activities in FY23; however, it will ramp up in FY24-25.

As the agency finalizes its reforestation strategy and implementation plans, there will be many opportunities for partners to engage. Reforestation needs on the landscape do not end at the border of USFS lands, and the agency will need help thinking about what reforestation needs look like on all lands (e.g., state, Tribal, private). The agency and partners also need to think about how to strengthen their collective capacity to implement reforestation and communicate/ message effectively about the need for and benefits of actions taken today. There is an opportunity for partners to come together to develop a shared vision of what success might look like, based on their collective experiences, and to convey that vision, and the tools that will be necessary (or already exist) to achieve that vision, to Congress and the agency.

Comprehensive Cross-Jurisdiction Planning

The National Cohesive Wildland Fire Management Strategy serves as a useful model for the development of a post-fire management response. This strategy looked cross-boundary, at multiple scales, and included involvement at all levels of government, non-profits and the public in its development. A multistakeholder, landscape scale, long-term strategy for reforestation could also more closely link post-fire management to the existing Cohesive Strategy.

A cohesive framework for managing post-fire landscapes at scale could involve partitioning the land to identify priority reforestation opportunities, evaluating the trajectories of change on those parcels (e.g., disturbance risk over various timeframes), and then prioritizing, implementing, and monitoring reforestation activities. Prioritization is important.

The new federal reforestation funding presents opportunities for comprehensive planning that crosses agencies, governmental levels, and the science and land manager communities. Major fires in the West over the last few years have burned across ownership boundaries, affecting federal, state, Tribal, private, and other owners, including forested watersheds relied on for water supplies. While much of the burned acres has been on USFS land, there are also significant reforestation needs on private lands where groups that specialize in working with private landowners can play an important role in reforestation. True landscape-scale reforestation and restoration will require cross-jurisdictional, cross-boundary approaches spanning both federal and non-federal lands. More coordinated, collaborative planning

approaches will help to create synergies among partners and help to identify barriers such as where workforce capacity is needed at local and regional scales.

There are already some efforts underway in the West to pursue comprehensive post-fire planning. In California, for example, there is a group of partners developing a California Reforestation Strategy that takes an all-lands perspective. In southcentral Oregon, there is, likewise, a group of partners working on an integrated, holistic post-fire restoration strategy. Experience in California suggests that a reforestation coordinator – a boundary-spanning position – could be helpful in breaking down silos and bridging actors, and some other states are exploring creating similar positions. Cross-jurisdiction planning can be tricky, though, as management goals in different jurisdictions vary and care must be taken to maintain cohesiveness across boundaries.

Pre-Fire & Post-Fire Linkages

A significant part of the bipartisan infrastructure law's forest-related funding was for reducing catastrophic wildfire risk across the West. The USFS has identified several initial landscapes it will focus on to reduce risk, through thinning and prescribed fire, work which may increase the ability of some forested areas to survive fire and reduce the need for future reforestation. Pre-fire management can reduce the severity and size of fires, and may change post-fire outcomes. For example, reducing the patch size of high-severity fires will benefit post-fire recovery by keeping seed sources within reasonable distance on the landscape.

Pre-fire preparation work can help in ways beyond reducing fire severity and size, and post-fire science can guide changes in pre-fire management. It is important to think about the desired post-fire response before the fire happens, as well as about the purpose of putting trees out on the landscape (e.g., timber, habitat, watershed protection). Doing so can enable faster, more effective, more strategic reforestation efforts after a fire occurs. For instance, programs to ensure adequate seed stock, nursery infrastructure, and a more robust seed tree network pre-fire could help ensure more seed sources are available in a post-fire environment. It is likewise important to think about sediment sources and sinks on the landscape and to refurbish sink areas, so when areas burn, post-fire techniques are already in place. Processes and frameworks (e.g., agreements, prioritization tools) also need to be established ahead of time so entities can go into post-fire environments with both thoughtfulness and urgency (in some landscapes, for example, there are only a few years post-fire before shrubs and brush take over).

Many forest-based collaboratives are focused on the pre-fire wildfire risk mitigation, impacting the way agencies and other partners design mitigation projects across boundaries. Extending the pre-fire collaborative structure into post-fire recovery may serve a similar role to share knowledge, break down organizational barriers, and coordinate across all lands. It could be the same collective bridging the pre- and post-fire sides, or it could be a different group for each. Either way, there is an opportunity to think more broadly about the desired goals on the landscape and to get out of the pre-fire and post-fire stovepipes.

Information, Expertise, & Experimentation

While the REPLANT Act has addressed the funding constraints for reforestation, there are other limiting factors, including a need for information, expertise, and experimentation.

Research and data are key needs. In reforestation activities at cross-boundary scales, geospatial data is needed to help make initial decisions about what activities to pursue, but datasets often have incomplete coverage. Rapid Assessment of Vegetation Condition after Wildfire (RAVG) fire severity mapping, for instance, is useful but is biased toward public lands. Many acres burned in recent years in California, for example, lack RAVG mapping, which means many land managers do not have the detailed data necessary to act quickly after wildfire. Likewise, research on post-fire recovery is limited with regard to compound disturbances (e.g., insects, disease, followed by fire). Datasets depicting where natural regeneration is occurring would be useful as well to direct reforestation efforts. There is also a need to continue to find sources of funding and to build and sustain support within research institutions for applied post-fire science work. Applied research is incredibly important to land managers.

It would also be beneficial to have a community of practice for people working on the ground to stay up to date on the latest science and to share experiences with others doing similar work. Land managers have limited opportunities to connect with each other to share practical challenges and experiences.

Building climate-informed reforestation knowledge should also be a key focus going forward. Reforestation activities peaked from about the 1960s-1990s, and many people with extensive experience are retiring or already retired across agencies. Institutional knowledge is in short supply, and as the climate changes, what worked in the past may need to be modified for the future. In some cases, younger staff have limited experience with planning complex reforestation projects, including managing funding and contracting and designing and overseeing the work on the ground. Spaces to share information, create learning opportunities and communicate knowledge, and set the foundation for collective action are vital, particularly across jurisdictions. Non-traditional partners, such as private industry, hold a lot of knowledge on how to reforest successfully, so being able to get people in rooms together to work cross-jurisdictionally and share expertise is a key opportunity. The more that these types of knowledge sharing and partnerships can be leveraged, the more likely it is that reforestation efforts will be successful.

There may also be troves of information in various places that are not being shared widely enough. Experimental forests, for example, have collected data for decades, and there may be relevant data to inform current decision-making. In addition to research, managers doing this work are also valuable allies, and individual planting projects can be used to yield more information about the success of outplanting. Getting land managers to use planting projects to test different ideas, e.g. thinking experimentally, is important, but challenging. Some managers are already experimenting, and there is the opportunity to more broadly share their experiences.

The US Forest Service builds on 100+ years of reforestation experience, but as the climate changes, their knowledge must quickly adapt to the new conditions. Business-as-usual approaches may not work well. Building the license for managers to be more experimental could be an opportunity to strengthen relationships between the R&D staff and National Forest System staff within the USFS. The need to build the license for experimental approaches applies to the broader public as well. Not all partners and communities are forward-looking, and exploring other approaches requires landowner permission to move in that direction.

Seed Stocks, Nursery Capacity,

Seeds are integral to reforestation, given that some species produce seeds episodically in multi-year cycles, meaning that planning for reforestation must occur 5-10 years before the need. There are concerns about access to adequate climate-specific seed stocks. The USFS has a network of nurseries and seed extractories that it has been making investments in over the years as resources have allowed, but new funding from the REPLANT Act will allow for increases in the capacity of reforestation supply and in capital investments in this infrastructure. The agency will also need to partner in this space to increase this capacity, including with state and other nurseries.

Planting at low densities and using nucleation plots can mimic natural regeneration on the landscape and help to foster future resilience. Planting farther from the live forest edge and utilizing small nucleation islands – at the desired density and spacing to be resilient to fire – allows for the gaps between islands (and to the edges) to be filled in for free over time. Some hypothesize that the larger gap between plots, might better protect some stands from future fire. Efforts to keep forest refugia intact through future fires are also important, as live trees on the landscape post-fire result in a higher abundance of seeds and thus greater regeneration.

Getting seedlings into the landscape is challenging work, involving extensive planning to get planting crews into the landscape and crews are generally limited to areas with road access, that are not on steep slopes. It will not be possible to plant all burned areas using traditional methods. Within burned areas, between half and two-thirds of the land may be accessible, suggesting a significant amount of the land where there may be opportunities to try other approaches, such as direct seeding. Field experiments on direct seeding in old and new fires found that ponderosa seeds — which are large and do not travel far — were heavily predated by deer mice in both types of landscapes, regardless of whether the seeds were uncoated, coated, or otherwise. The seeds that were not predated mostly germinated, regardless of the coating or treatment. Direct seeding, particularly early on post-fire before the small mammal population has time to skyrocket, can successfully produce seedlings on the landscape. Sprinkling seeds in mulch that was dumped as part of aerial mulching in high-severity patches has also produced some seedlings. Plans for these types of seeding approaches have to be in place pre-fire, as the seeding has to happen within the first year or two after a fire in order to be a viable solution. A barrier to direct seeding, though, is the need for far greater seed stocks than for traditional reforestation, and seeds are precious now.

Beyond getting seedlings into the landscape, it is important to think about where seedlings should be placed to improve their odds of survival. In some reforestation efforts, there has been a higher percentage of seedling survival on north-facing aspects and at higher elevations, where water is better retained. Seedling size can also affect survival rates; in some places and conditions, larger seedlings fare better. In general, low seedling survival rates are a common challenge for reforestation projects. It would be useful to monitor planted and naturally occurring seedlings to gauge whether the mortality of each type is the same or different — or, to the extent that such experiments have already been done, to access and share that data more broadly.

Other Considerations and Challenges in Implementation

In addition to a shortage of seed stocks, other barriers to large-scale reforestation include:

- Workforce capacity: The pool of skilled individuals is limited and often available during windows that are inappropriate for planting. The workforce capacity issue has to be addressed, both on-the-ground (e.g., crews) and in administrative positions (e.g., contracting officers).

- Reforestation demand outpaces supply: In addition to the preparation needs on the supply side in terms of seed collection, labor, infrastructure, and the like, the demand side of reforestation must also be considered. There are places that need reforestation but lack the resources, knowledge, and support to engage in reforestation activities. On the other hand, working to support this demand means additional competition for limited reforestation resources.

- Equity: Equity should be at the forefront of reforestation efforts, as it is important that conservation and environmental agencies engage in respectful and equitable ways with communities regarding long-term post-fire planning.