NORTHERN ARIZONA UNIVERSITY | Ecological Restoration Institute

The Ecological Restoration Institute at Northern Arizona University

Accelerating Restoration and Resiliency in the West

Fiscal Year 2022 Work Plan

June 1, 2022

Introduction

In 2004, Congress passed the Southwest Forest Health and Wildfire Prevention Act (PL108-317; hereby referred to as the Act) that established three university-led Southwest Ecological Restoration Institutes (SWERI) in Arizona, New Mexico, and Colorado. The Act was a result of congressional recognition, led by US Senator Jon Kyl from Arizona, that objective, practitioner-oriented science was needed to accelerate forest restoration across public lands and across boundaries. In the early 2000s, confidence in Forest Service management was low, leading to objections and litigation that confounded forest management. Senator Kyl viewed the objectivity of university-based knowledge as a cornerstone for building public support for action. Today, the SWERI are recognized for consistently identifying ever-changing management questions and gaps, and developing actionable, and scientifically credible, solutions to those gaps. We work as science partners, collaborators, and conveners for all our affected entities.[1] Growing recognition of the SWERI by Congress is evidence of the capacity of the institutes to provide timely, evidence-based information to facilitate restoration in a complex forest management environment. The three institutes are increasingly collaborating on projects in their annual work plans to increase West-wide impacts across multiple focal areas.

The Ecological Restoration Institute's leadership team uses the 2020–2024 Strategic Plan as a guide for work plan development, as it captures the mission of the ERI and its commitment to fulfilling the Duties and Purposes of the Act. These include: 1) developing, researching, and monitoring treatments to reduce the risk of severe wildfires and improve the health of dry forests and woodlands; 2) synthesizing and adapting scientific findings for affected entities to implement treatments on a landscape scale; 3) translating and transferring knowledge to all affected entities; 4) assisting all affected entities to implement treatments using best adaptive management practices and, 5) providing a report on all deliverables. The ERI's mission is to serve diverse audiences with objective science and implementation strategies that support ecological restoration and climate adaptation on western forest landscapes. In addition, ERI staff work collaboratively with partners in work plan development each year. In particular, to build this year's work plan:

- Staff coordinated with the Colorado Forest Restoration Institute and the New Mexico Forest and Watershed Restoration Institute to identify and meet cross-region and national needs.
- Staff continued conversations with the Resource Integration Management Coordination team in the WO to better inform our monitoring and adaptive management work.

[1] *An affected entity is defined in PL108-317 as: land managers, stakeholders, concerned citizens; and, the States of theinterior West, including political subdivisions of the States.*

- Across Region 3, staff consulted with the US Forest Service Regional Office (SWERI Coordinator, Director, Ecosystem Analysis and Planning, Ecologist, and Climate Change Coordinator), forest-level staff on the Tonto, Prescott, Coconino, Coronado, and Kaibab, and the 4FRI Implementation team to determine land management support.
- Staff identified ongoing Collaborative Forest Landscape Restoration Program (CFLRP) needs in consultation with Lindsay Buchanan (CFLRP Coordinator) and CFLRP stakeholders from pilots across the intermountain West.
- Staff worked with the 4FRI stakeholders, Forest Service, and Rocky Mountain Research Station staff to identify and validate ongoing ERI technical and administrative services to the 4FRI Stakeholder Group.
- Staff consulted with the Forest Products Modernization Team (US Forest Service, The Nature Conservancy) to advance innovation for restoration outcomes on federal landscapes.
- Staff consulted with the Intertribal Timber Council, representatives from individual Tribes including the Navajo Nation, San Carlos Apache, Mescalero Apache, and Hualapai Nation and the R-3 Regional Office (Liv Fettermen), forest tribal liaisons, and the Bureau of Indian Affairs at the regional and central office levels to identify strategic opportunities to assist Tribes.
- Staff discussed ways to improve biomass utilization opportunities with the USFS Regional Office, USFS Washington Office, and Rocky Mountain Research Station staff.
- Staff communicated with the Arizona Department of Forestry and Fire Management to discuss opportunities for shared stewardship and advancing state restoration and fire risk reduction goals.
- Staff responded to literature gaps identified from past work plan efforts, including systematic reviews, and evaluation of long-term monitoring sites.
- Staff worked with managers, scientists, policy makers, and various agency partners to identify both current and anticipated science needs. The ERI uses various strategies, including long-term monitoring, manager and public surveys, analysis of landscape-scale remote sensing data, and implementation of new studies to provide timely, actionable science-based information.

Focal Area Summaries

The ERI continues our six interdisciplinary focal area categories for Fiscal Year 2022 (FY22). These categories leverage work at the Colorado and New Mexico institutes and are consistent with the purposes and duties of the Act.

Our FY22 focal areas help support current Forest Service initiatives, including filling gaps in under-studied ecosystems; working across boundaries on restoration planning and implementation with multiple partners under Shared Stewardship; contributing support to tribal implementation of Tribal Forest Protection Act (TFPA) projects using 638 (PL93-638) agreements and biomass utilization projects; advancing wood utilization from restoration projects; and addressing climate change impacts and adaptation opportunities available to federal land managers across Region 3.

Focal Area 1 – Restoration and climate adaptation knowledge development and transfer *(Fulfills duties under the Act: 1, 2, and 3).* In FY22, the ERI will monitor climate-related changes in forest structure and composition, including regeneration and tree mortality patterns following 20 years of drought. This builds on the FY21 San Francisco Peaks project (see progress report 2021). In addition, research staff will analyze how managed fire policies and directives are interpreted and implemented by managers among multiple federal agencies with varying missions and leadership intent, to better understand the realities and impacts of managed wildfire decisions.

Focal Area 2 – Apply ERI expertise to restoration implementation at appropriate scales (*Fulfills duties under the Act: 2, 3, and 4).* In this focal area, the ERI applies interdisciplinary expertise to address barriers and challenges to restoration implementation, at scales appropriate for enhancing resiliency for forested landscapes and human communities.

Focal Area 3 – Foster and support partnerships *(Fulfills duties under the Act: 2 and 3).* The ERI convenes and facilitates discussions that advance restoration knowledge development and application across boundaries and at landscape scales.

Focal Area 4 – Integration and engagement with tribal land restoration *(Fulfills duties under the Act: 2, 3, and 4).* The ERI, with Northern Arizona University, is committed to facilitating the exchange of restoration knowledge and experience between and among tribal and federal partners.

Focal Area 5 – Science and policy application and interpretation *(Fulfills duties under the Act: 3 and 4).* The ERI develops workshops, field trips, and focus groups to work with all affected entities for shared science delivery, and implementation of state and federal agency strategic goals.

Focal Area 6 – Communication and outreach *(Fulfills duties under the Act: 3).* The ERI is proud to be a known expert in forest restoration science and implementation. To meet the duties of the Act, we promptly respond to media requests, community information needs, policy questions, and practitioner information requests on a weekly basis.

Focal Area Descriptions and Deliverables

Focal Area 1: Restoration and climate adaptation knowledge development and transfer

Focal Area 1 describes ERI's work to address existing and emerging biophysical and social science needs related to issues such as restoration treatment effectiveness, climate impacts on forests, and understudied forest ecosystems, as well as understanding the social, economic, and policy barriers to forest restoration and wildfire risk mitigation. Efforts in this project include analysis of long-term monitoring data collected on field plots, analysis of landscape-scale remote sensing data, implementation of new studies to investigate key questions aimed at accelerating the pace and scale of restoration, and social and economic research with managers and other affected entities. Science delivery of critical information to land managers and other stakeholders is completed through peer-reviewed technical publications, working papers, fact sheets, conferences, and workshops to best meet the requirements of a wide audience of practitioners, researchers, and policy makers.

Mortality of dominant tree species and expansion of species into new habitats are climate-driven changes that are expected to be most prominent in transition zones where species occur at their environmental limits and in communities with narrow habitat parameters. Information concerning types and rates of change in locally uncommon and critically important forest systems is needed for managers to refine treatment priority strategies and more effectively plan activities across landscapes. In FY22 (Project 1.2), the ERI will capitalize on an extensive array of monitoring plots that we established along a steep elevation gradient in 2000–2003, and continue plot remeasurements to assess patterns of tree mortality and regeneration in aspen forests and examine expansion of aspen into forests at upper elevations. This unique landscape analysis will require a multi-year approach, and in FY22, the ERI will build on the initial re-sampling done in FY21. Interim information produced in this project will be highly valuable for local and regional managers concerned with impacts of climate change on forests landscapes and wilderness management.

Pinyon-juniper (PJ) ecosystems cover vast extents of southwestern landscapes, but this forest type is highly variable in structure and function, and presently there is high interest among managers concerning restoration and fuels management appropriate for PJ. Woodlands provide important goods and services, including habitat for wildlife species such as the pinyon jay, pinyon "nuts," and fuelwood. In addition, intensive livestock grazing and fire exclusion in adjacent grasslands and shrublands have been linked to expansion of pinyon and juniper trees into these areas. Thus, understanding dynamics and recent structural changes of PJ woodlands, especially as affected by climate and insect outbreaks, are important to land managers. In FY22, the ERI will investigate mortality and crown dieback in pinyon and juniper trees occurring in persistent woodlands and expansion zones of northern Arizona. Information from this project will allow managers to better conserve old pinyon pine trees as well as develop more effective restoration treatments. In addition, we will continue our collaboration with Dr. Andy Graves (Forest Health Protection, NM Zone) to examine effects of thinning and alternative slash treatments on forest structure, subsequent bark beetle attack, and understory community responses (continued from FY21). Information generated from this work will help managers when considering timing of fuel reduction treatments and tradeoffs that may be associated with meeting restoration goals.

The ERI will use data from its network of long-term restoration study sites to analyze interactions of climate and restoration treatments and their effects on tree growth. Tree increment cores and data for this project were collected for other projects in previous fiscal years (see multi-site overstory analysis, FY20, and multi-site understory findings, FY21; also see past ERI annual reports and work plans), and in this way, the ERI will leverage its long history of restoration monitoring to answer important questions related to ecological resilience. Information from this study will help managers better anticipate outcomes of restoration treatments for sustaining forest benefits over time.

Climate change is increasing the impacts of southwestern common disturbances such as drought, fire, and insect attack, with high vulnerabilities to type conversion in many systems. Disturbance refugia — the landscape locations that are, relative to adjacent locations, more likely to resist disturbance (i.e., greater tree survival during a disturbance) — contribute to forest resilience in the surrounding area due to seed dispersal from surviving trees. While refugia concepts are increasingly incorporated into ecological research, an understanding of where refugia exist in southwestern US landscapes may also inform broad-scale land management strategies. This is a new project, built on published literature and anticipatory of expected Southwest management needs. Such information will provide managers with an understanding of where trees are most likely to survive fire and resist future drought, which will aid in restoration and fuels reduction treatment prioritization at local and regional scales.

It is increasingly common for land managers to use wildfire to accomplish ecological restoration objectives. The use of wildfire can be accomplished through prescribed fire (i.e., planned ignitions) or managing wildfires with an "other than full suppression" (OTFS) objective, which is commonly referred to as "managed wildfire." Managed wildfires can encompass a wide range of scenarios, including managing natural ignitions for resource objectives (i.e., resource objective (RO) fires) or otherwise using wildfires to achieve community fire risk reduction and ecological benefits. Managed wildfire use is increasingly promoted as a tool to increase the pace and scale of restoration, but at the same time, there are concerns about wildfires that escape control or behave unexpectedly and result in negative outcomes. Furthermore, there are numerous different decision support tools and frameworks (i.e., Risk Management Assistance (RMA) tools or Potential Operational Delineations (PODs)) that can be used to inform decision making on managed wildfires but the use and effects of which are not well understood. In FY22, we will continue a study initiated in FY21 that is documenting managed

wildfire policies and directives across agencies, as well as assessing how policies and directives are interpreted in decision making on the ground. This work will add to the growing body of research, including ERI research (Huffman et al. 2017 and Huffman et al. 2020) from past work plans, on managed wildfire and inform the creation of policies and decision support tools that ensure the effective use of fire to accomplish ecological restoration objectives.

Focal Area 1: Restoration and climate adaptation knowledge development and transfer *Fulfills duties under the Act: 1, 2, 3*	
Action	**Requestor/Anticipatory**
1.1) San Francisco Peaks ecosystem monitoring	Requestor: Mark Nabel, Silviculturist Coconino National Forest Outcome: Information on long-term impacts of drought and climate change in aspen and other higher-elevation forests; inform future planning for landscapes and wilderness areas
1.2) Pinyon-juniper stand dynamics and treatment responses *a) Climate- and insect-driven changes in pinyon-juniper woodlands and expansion zones* *b) Mt. Taylor (NM) pinyon-juniper thinning and slash treatments*	Requestor: Multiple units; Andy Graves, Forest Service Forest Health Protection NM Zone Lead Outcomes: a) Information on impacts and management implications of tree mortality and crown dieback in different PJ structural types; b) Information on tree mortality and understory responses to pinyon-juniper thinning and slash treatments
1.3) LEARN tree growth analysis	Requestor: Forest Service Outcome: Analyze interactions between climate resiliency and restoration treatments through effects on tree growth
1.4) Disturbance refugia in the four-corner states	Requestor: Anticipatory Outcome: Information on the likely locations of disturbance refugia, which may then be used to incorporate landscape context into silvicultural prescriptions
1.5) Human dimensions of managed wildfires	Requestor: Congress Outcome: Will inform future policy and decision support tools
1.6) Systematic review and science summary	Requestor: Anticipatory Outcome: Support to other funded systematic review needs; will inform future planning

1.1) San Francisco Peaks ecosystem monitoring. This work fulfills several ERI strategic goals related to analysis of landscape processes and climate change effects in forest ecosystems, and continues FY21 work to provide new information on understudied ecosystems. The overarching aim of this multi-year effort is to assist managers in planning for climate change and landscape-scale restoration. Information from this project will also help managers identify goals for managing a wilderness landscape that is of major importance to Flagstaff and local tribes. In FY22, we will remeasure long-term monitoring plots to analyze tree mortality and expansion of aspen into adjacent forest types.

Requestor: Coconino National Forest, Flagstaff Ranger District, City of Flagstaff, Coconino County, and Anticipatory
Outcome: Information on long-term impacts of drought and climate change in aspen and other higher-elevation forests; inform future planning for landscapes and wilderness areas

Deliverable:
a) Presentation on sampling and results for local managers and/or other stakeholders

1.2) Pinyon-juniper stand dynamics and treatment responses. This work examines management questions related to climate impacts, restoration, and hazardous fuels reduction treatments in pinyon-juniper (PJ) ecosystems. Although PJ systems are extensive in the western United States, information concerning restoration treatments that align with historical ranges of variation and long-term impacts of warming/drying climatic conditions is lacking. The ERI has identified PJ as an understudied ecosystem. Project 1.2a will examine implications of recent tree mortality and crown dieback in PJ systems of northern Arizona. This work will help managers develop strategies to conserve important attributes of persistent woodlands and restore grassland and shrubland habitats. Project 1.2b is an ongoing effort conducted as an ERI collaboration with Forest Service Forest Health Protection (FHP) NM Zone Lead Andy Graves using an experimental design established in 2019. Work will include field data collection on understory and fuels responses to hazardous fuels reduction and slash treatments, and may entail assisting with analysis of other data collected by the New Mexico Forest and Watershed Restoration Institute or other entities.

Requestor: Multiple units; Andy Graves, FHP, New Mexico Zone Lead
Outcome: Analysis of structural changes due to drought, warming temperatures, and insect outbreaks. Analysis of understory responses to PJ treatments to inform future planning

Deliverables:
a) Climate- and insect-driven changes in pinyon and juniper woodlands and expansion zones
    i) Technical report on results of structural change analysis
    ii) Presentation to affected entities/stakeholders
b) Mt. Taylor, New Mexico, pinyon and juniper woodland thinning and slash treatments
    i) Progress report for Forest Service collaborators

1.3) LEARN tree growth analysis. The ERI will leverage tree increment core samples and long-term data from its network of ponderosa pine restoration study sites to analyze effects of climate and restoration treatment interactions on tree growth and mortality. Recent preliminary work has suggested that old, pre-fire exclusion ponderosa pine trees in areas receiving restoration treatments show higher rates of growth and faster recovery after drought years than trees in untreated areas. To date, there have been no comprehensive studies to examine tree responses to restoration treatments across gradients of site conditions and climatic regimes. Information from

this extensive analysis will help managers better anticipate outcomes of restoration treatments for sustaining tree growth and forest benefits over time.

Requestor: Anticipatory; Forest Service
Outcome: Analysis of long-term tree growth responses to restoration treatments.

Deliverable:
a) Technical report for publication

1.4) Disturbance and climate refugia in the four-corners states. The ERI will work with the Colorado and New Mexico institutes and additional partners, including RMRS and Colorado TNC, to build datasets and information that provide managers with an understanding of where trees are most likely to survive fire and resist future drought. The project partners will use fire severity and drought resistance datasets derived from remote-sensing, in combination with climate/terrain variables, to map the locations of fire and drought refugia throughout forested ecosystems in Arizona, Colorado, New Mexico, and Utah, USA. Maps may aid restoration and fuels reduction treatment prioritization at local and regional scales. This project is intended to be multi-year and will produce a peer-reviewed manuscript, a spatial decision support tool, and publicly available spatial datasets in FY23.

Requestor: Anticipatory
Outcome: Information on the likely locations of disturbance refugia, which then may be used to incorporate landscape context into silvicultural prescriptions

Deliverables:
a) Progress report
b) Science delivery outreach that may include either a StoryMap, Visme, or another web-based interpretative tool

1.5) Human dimensions of fires managed for resource benefit. In FY21, we cataloged and analyzed managed wildfire policies, directives, and guidance documents, as well as began to document the factors that influenced managed wildfire decisions. In FY22, we are continuing this work into a larger project designed to understand how managers interpret policy and guidance for managed wildfires, what tools and resources managers use to inform decisions, and how this varies across jurisdictional entities and landscapes in coordination with the other SWERI. This will allow us to assess how policy and guidance interpretations, decision support tools, and other key factors influence managed wildfire decisions. This will provide important information about how decision-making factors ultimately influence the ecological outcomes of managed wildfires. Because the use of managed wildfire is guided by policy but interpreted differently by managers across different jurisdictional entities and landscapes with different decision contexts, we surmise that the ecological outcomes of managed wildfires reflect how policy, acceptable levels of risk, and other decision factors are interpreted by managers on the ground.

Requestor: Congressional request of SWERI — examines the efficacy of current and proposed policy directions
Outcome: Understanding policy interpretation and effectiveness; will inform future policy

Deliverables:
a) White Paper on managed wildfire policies
b) Workshop or workshop session with managers, scientists, and stakeholders on managed wildfire and associated report

1.6) Systematic review and science summary. Work in FY22 will support fuel treatment effectiveness systematic reviews and summaries, which are funded by alternative sources.

Requestor: Congress
Outcome: Co-author research, analysis and writing support to multi-author syntheses

Deliverable:
a) Draft manuscript

Focal Area 2: Apply ERI expertise to restoration implementation at appropriate scales

The ERI has long championed forest restoration at scales appropriate to the ecological disturbances and threats facing our public lands. In 2022, we will address science gaps and information needs across disciplines to further advance restoration implementation at appropriate scales.

The ERI works to create strategies to economically and efficiently utilize small wood and biomass resulting from restoration treatments. Our program, led by Dr. Han-Sup Han, leverages successful competitive grants that fund much of the work under this research area. Partnerships with NAU and Coconino County are informing workforce needs and advancing the opportunity for a workforce training facility in northern Arizona to fill gaps for skilled workers in the forest industry. There is a need to run this work over multiple years, as there is a West-wide need for evaluation of rail transportation capacity and opportunities.

Landscape-scale forest restoration efforts continue to be challenged by a lack of full cost-benefit analyses to restored acres. To date, there is little information about the inherent value a restored acre provides to society and communities. Through a decade of landscape-scale, congressionally funded projects, western public land managers and stakeholders have a better understanding of how a restoration timber product-based model cannot support restoration at the scale needed to mitigate catastrophic wildfire and climate change impacts. In 2021, work was done to accumulate the literature available on benefits from a restored acre tied to valuation. We will continue the project in 2022, identifying the gaps and using multiple ecosystem service valuations and avoided wildfire costs, to better evaluate the return on investment from restoration treatments on federal lands.

Since 2017, the ERI has worked in partnership with the Forest Service, including the Forest Products Modernization team, The Nature Conservancy, and other partners to facilitate innovation and modernization approaches that will reduce the time and cost of implementing restoration treatments. In FY22, the ERI will continue to facilitate the development of the Digital Timber Sale Manager (DTSM) pilot, which is a system that will manage spatial data for the life of a timber sale and help improve efficiency in restoration treatment implementation.

As changing climatic conditions continue to influence the size and intensity of today's wildfires, it is critical that the solution fits the scale of the problem, requiring landscape-scale efforts across the West. But, implementation barriers persist. Scaling up operations will depend on strategic prioritization and planning to direct mechanical treatments — and emerging industry — to the most strategic, high-valued acres in need of restoration. By incorporating landscape features and past disturbances that influence landscape fire potential, wildlife habitat quality, and community protection, planned-for mechanical and fire treatment implementation can be better optimized to efficiently reach desired conditions. If we work strategically, we can mitigate the losses while industry continues to innovate and ramp up to meet mechanical needs.

Focal Area 2: Apply ERI expertise to restoration implementation at appropriate scales *Fulfills duties under the Act: 2, 3, 4*	
Action	**Requestor/Anticipatory**
2.1) Expanding the capacity of forest operations and biomass utilization	Requestor: Multiple stakeholders, state and local municipalities, forest product businesses Outcome: Rural economic development to benefit sustainable land management; expanding markets for wood; informing job training needs
2.2) Facilitate the development and integration of new technologies to advance restoration implementation	Requestor: Forest Service Forest Products Modernization Team, The Nature Conservancy Outcome: Lessons learned; informing future implementation processes
2.3) Understanding the value of a restored acre	Requestor: 4FRI Chief Executive, policy makers Outcome: Additional project evaluation methods through a return on investment analysis to develop value of a restored acre; will inform accomplishment reporting and economic and non-market outcomes
2.4) Landscape prioritization and strategic implementation	Requestor: Anticipatory Outcome: Landscape-scale prioritizations; increase efficiencies; inform implementation and fire incident response planning

2.1) Expanding the capacity of forest operations and biomass utilization. This ERI program area works to expand industrial capacity and markets to utilize small-diameter wood and biomass. These projects are mostly supported by a mix of external grants and state funding. The federal work plan will support this broad program area in the following ways:

a) The implementation of the **Forest Operations Training Program** is supported by an external grant (US Economic Development Administration); however, the ERI will provide additional support for partnership development and communication, including coordination with state agencies and elected officials, press releases, etc.

b) ERI staff will also support and leverage two externally funded projects: 1) a project funded by a USDA Forest Service Wood Innovations Grant that brings together partners from three neighboring states (Arizona, New Mexico, and Colorado; SWERI Wood Utilization Team) to strengthen the forest products industry and increase the pace and scale of forest restoration; and 2) to better understand the costs of mechanical thinning treatments in the US West — this project will examine what factors are influential in determining these costs and how they vary by region. This second project is funded by the state of Arizona and USDA Forest Service's Rocky Mountain Research Station.

Requestor: State and local municipalities
Outcome: Rural economic development that benefits sustainable federal land management needs

Deliverable:

a) Report on support and a fact sheet of the grant-funded journal publication.

2.2) Facilitate the development and integration of new technologies to advance restoration implementation. In FY22, the ERI is adding capacity to the development of a Digital Timber Sale Manager (DTSM) pilot, which is a digital system that will manage spatial data for the life of a timber sale to improve efficiency in restoration implementation, for use within the Four Forest Restoration Initiative (4FRI) project in partnership with The Nature Conservancy and Forest Service, including the Forest Products Modernization Team. In FY22, the ERI will continue convening and facilitating the development of the DTSM pilot, as well as capturing and communicating lessons learned from the pilot that may serve as a guide for the integration of new technologies in Forest Service implementation processes beyond the 4FRI area.

Requestor: Forest Service Forest Products Modernization Team, The Nature Conservancy, USFS Region 3
Outcome: Lessons learned from innovative project planning, to inform future implementation processes

Deliverable:

a) Progress report

2.3) Understanding potential performance measures through a forest restoration cost-benefit analysis. Using multiple ecosystem service valuations, ERI research on treatment effectiveness, and full cost accounting measures of previous wildfires, the ERI will work with an economist to conduct a pilot study of potential avoided wildfire costs through restoration treatments. This two-year project will continue work initiated in the FY21 work plan. The contractor will continue to synthesize the costs of wildfire and additionally assess the potential return on investment from restoration treatments to begin to better quantify the economic and non-market benefits of restoration treatments versus the economic impacts of wildfire suppression and mitigation on federal lands. This project will help to inform the development of appropriate performance measures or outcome metrics for restoration work.

Requestor: 4FRI Chief Executive and policy makers
Outcome: Economic measures of the potential avoided costs of wildfire to help quantify the return on investment in restoration treatments to inform accomplishment reporting and economic outcomes.

Deliverable:

a) Draft journal article, or working paper

2.4) Landscape prioritization and strategic implementation. As project planning increases to millions of acres in scale, there is a need for strategic prioritization and planning to implement restoration treatments. By incorporating landscape features and past disturbances that influence landscape fire potential, wildlife habitat quality, and community protection, the planned-for mechanical and fire treatment implementation can better be optimized to efficiently reach desired conditions. There is potential to work across the SWERI, including collaboration with CFRI (PODs and other CFRI work) to address a 4FRI need.

Requestor: Anticipatory, 4FRI, and Kaibab NF
Outcome: Landscape scale prioritizations to increase efficiencies and inform implementation and fire incident response planning.

Deliverable:
a) Technical report or peer reviewed publication

Focal Area 3: Foster and support partnerships. *Convene and facilitate discussions that advance restoration knowledge development and application across all lands.*

In addition to science translation, the ERI has been and continues to develop, facilitate, and support partnerships and collaborations to advance forest restoration at appropriate scales and across ownership boundaries.

In northern Arizona, our Forest Service and collaborative partners have developed and approved more than a million acres for restoration treatments. In FY22, ERI staff will contribute leadership and technical support to the 4FRI Forest Service team and stakeholder group. Work on the 1st EIS area (Coconino and Kaibab national forests) includes multi-party monitoring, and the innovative implementation identified in Focal Area 2, above. With the final decision on the Rim Country EIS expected spring 2022, ERI support will transition from planning efforts to translation of collaborative desired conditions for implementation. Stakeholder group leadership will continue.

ERI supports collaborative, science-based restoration efforts, such as those under the Collaborative Forest Landscape Restoration (CFLR) Act, through webinars, field trips, participation, and coordination of workshops and other services. For example, the ERI is a knowledge expert in the area of monitoring and adaptive management. In FY22, we are expanding the development of a core social monitoring indicator for collaborative health, function, resilience, and outcomes on newly funded CFLR projects with the Forest Service Washington Office and the other SWERI. This monitoring indicator was piloted on one CFLR project funded in FY21 and will be expanded to an additional 13–17 newly funded CFLR projects in FY22.

The ERI is pleased to help implement the national focus on the Wildfire Crisis Strategy, and cross-boundary needs at state, region, and western scales. In FY22, this includes across-SWERI and with multiple partners, leverage lessons learned from affected entities across the West. Continued Covid-19 shut downs and travel restrictions required the postponement of the 2022 Cross-Boundary Workshop. We will host this workshop in hybrid format, with a variety of partners, in April 2023. Additionally, work with Arizona state agencies and partners will continue to expand relationships with communities to address gaps in cross-boundary fire management, and operational bottlenecks for forest biomass utilization and fire preventions.

Focal Area 3: Foster and support partnerships *Fulfills duties under the Act: 2, 3*	
Action	**Requestor/Anticipatory**
3.1) Support and science delivery for the 4FRI collaborative project	Requestor: Forest Service and northern Arizona stakeholders Outcome: Best available science for landscape restoration, landscape prioritization, monitoring assistance, and effective science collaboration
3.2) Kaibab National Forest Burnt Corral	Requestor: Kaibab National Forest and North Rim stakeholders Outcome: Best available science to meet project desired conditions of fire risk reduction
3.3) Development of a collaborative governance indicator for national CFLRP monitoring	Requestor: Forest Service CFLRP Coordinator Lindsay Buchanan Outcome: A national core monitoring indicator for collaborative governance and resiliency
3.4) Risk Management Assistance (RMA) and Potential Operational Delineation (POD) use on wildfire incidents	Requestor: Risk Management Assistance Team (Rick Stratton, Forest Service Fire and Aviation Management; Dave Calkin, Rocky Mountain Research Station) Outcome: Findings and recommendations to inform RMA/POD use
3.5) Support for wildfire crisis strategy	Requestor: Forest Service, AZ State DFFM, and Flagstaff Fire District Outcome: Increased shared fire risk mitigation across Arizona
3.6) SWERI partnership and across-region science delivery	Requestor: Forest Service, all affected entities Outcome: Shared landscape restoration best practices

3.1) Support and science delivery for the 4FRI collaborative project. The ERI has provided leadership, administration, and science support to the 4FRI collaborative project since the 2009 request for proposals. The 4FRI project was not selected for the national CFLRP reauthorization; however, this does not mean the collaborative and Forest Service project is ending. The ERI is committed to continued partnership in the multi-stakeholder partnership to realize the 2.4-million-acre forest restoration

Requestor: Forest Service and northern Arizona stakeholders
Outcome: Use of best available science for landscape restoration, monitoring assistance, and effective collaborative operations

Deliverables:

a) Report on leadership activities and work group technical support for 4FRI Stakeholder Group and working groups
b) Report on administrative support to facilitate effective collaborative operations; and IT support for the 4FRI website and BASECAMP; and administrative support

3.2) Kaibab National Forest Burnt Corral. Provide forest ecology science support for collaborative development and technical optimization work.

Requestor: Forest Service and northern Arizona and southern Utah stakeholders
Outcome: Use of best available science for North Kaibab landscape restoration, monitoring assistance, and effective collaborative operations

Deliverables:

a) Report on activities

3.3) Socio-economic monitoring and science delivery for the USDA Collaborative Forest Landscape Restoration Program. In FY22, the ERI, in coordination with the other SWERI and the Forest Service CFLRP coordinator, will expand the implementation of a core socio-economic monitoring indicator for CFLR projects. The SWERI are working to inventory and document information pertaining to the collaborative function, health, governance, and resilience of CFLR projects. In FY21, a core social monitoring indicator was piloted on the Northern Blues CFLRP, and in FY22, this indicator will be expanded to 13–17 newly funded CFLRPs throughout the country in coordination with the CFLRP program leaders, regional coordinators, and CFLRP participants. The SWERI are co-developing this monitoring indicator with the Forest Service WO to ensure that the information collected by SWERI supplements the national core CFLRP monitoring requirements. The SWERI will work with CFLRP collaborators to disseminate learning about collaborative resilience to the newly funded CFLR projects, the Forest Service WO and regional coordinators, and Congress to provide information about the social outcomes of the CFLRP.

Requestor: Forest Service CFLRP Coordinator Lindsay Buchanan
Outcome: A national monitoring indicator for collaborative governance and resiliency

Deliverables:

a) In partnership with SWERI, a report to Forest Service and Congress, or white paper
b) Dissemination of findings to the 13-17 CFLR projects

3.4) Risk Management Assistance (RMA) use on wildfire incidents. The use of spatial wildfire analytical and decision support tools is increasing to support complex decision-making environments on wildfire incidents, but there is a limited understanding of how effective these decision support tools are and what conditions support their use (FY20 Outcomes, Colavito 2021). In FY22, in collaboration with the other SWERI and the Forest Service RMA team, ERI will assist in completing analysis and disseminating findings from an assessment conducted in spring 2022 with fire managers, line officers, and incident management teams to determine if and how RMA products were used on wildfire incidents in the 2021 wildfire season. This assessment will be repeated in the spring of 2023 to examine the use of RMA

products on wildfire incidents in the 2022 fire. The assessment work will be conducted with ERI leveraged funding. Additional follow-up interviews will be conducted to better understand assessment findings and case studies developed to explore lessons learned in greater detail.

Requestor: Risk Management Assistance Team (Rick Stratton, Forest Service Fire and Aviation Management; Dave Calkin, Rocky Mountain Research Station)
Outcome: Findings and recommendations to inform RMA/POD use

Deliverables: A report on findings for the Forest Service Risk Management Assistance Team
a) In partnership with SWERI, a report to Forest Service and Congress or white paper
b) Dissemination of findings to the 13–17 CFLR projects

3.5) Support for wildfire crisis strategy. The ERI will assist in creating greater state capacity to reduce wildfire fuels around our communities, making greater use of partner capacity to reduce wildfire fuels, and increasing partnerships to reduce wildfire risks on federal lands neighboring our communities. In addition, the ERI partners with AZ DFFM Northern District, and local municipal fire stations.

Additionally, the ERI will facilitate the development of Tribal Forest Protection Act (TFPA) project proposals with southwestern tribal entities. Increased funding for TFPA proposals has increased the potential of their use. TFPA project proposals provide opportunities for Tribes to engage in forest level programs that support Forest Service Shared Stewardship initiatives.

Requestor: Forest Service, AZ State DFFM, and City of Flagstaff Wildland Fire Management
Outcome: Increased shared stewardship across Arizona

Deliverable*:*
a) Report on support to the Wildfire Crisis Strategy federal and state partners
b) Report on forest level and Tribal programs' use of TFPA agreements to advance cross-boundary collaboration

3.6) SWERI partnership and across-region science delivery. The three SWERI are uniquely positioned to synthesize and share science outreach and delivery. Currently, the SWERI coordinate to leverage monitoring knowledge, to realize cross-region biomass utilization grant outcomes, and develop cross-boundary shared learning. The ERI works — with support from all SWERI — to maintain staff expertise in the latest science, management, and policy strategies.

Requestor: Forest Service, all affected entities
Outcome: Cross-boundary, cross-state, and cross-region shared learning

Deliverable*:*
a) 2023 Cross-Boundary Workshop, April 2023, Ft. Collins, CO

Focal Area 4: Integration and engagement with tribal land restoration

During the last two years, the ERI has conducted outreach and engaged in conversations to identify needs and opportunities among numerous tribal representatives. A recent example includes the multi-partner effort, Wood for Life (WFL), that developed in the last year to provide firewood to Navajo, Hopi, and San Juan Southern Paiute homes. In FY22, the ERI is proposing to work with the WFL partnership to help identify and articulate fuelwood needs on tribal lands, assess capabilities, facilitate

establishing tribal partnerships, and document barriers, opportunities, and lessons learned from the WFL partnerships.

Additional work with tribal partners will focus on Shared Stewardship opportunities that may develop due to new contracting authorities and new initiatives promoting biomass utilization. Work in FY22 will include a workshop to exchange restoration knowledge among tribal members and with their federal neighbors. Work will also continue to engage tribes in cross-boundary biomass utilization pilots. Other requests include advising the Forest Service on use of newly authorized 638 contracting authorities and request from tribes for technical assistance.

The ERI will partner with the Intertribal Timber Council (ITC), the Nature Conservancy (TNC), Salish-Kootenai College (SKC) TREES program, the School of Forestry, Ecotrust, and the New Mexico Forest and Watershed Health Institute (NMFWHI) to host the 2nd Tribal Forestry Student Summit on the NAU campus. This Student Summit supports the Tribal Forest Workforce Development Strategic Plan developed by the Indian Forest Management Assessment Team III (IFMATIII).

Focal Area 4: Integration and engagement with tribal land restoration *Fulfills duties under the Act: 2, 3, 4*	
Action	**Requestor/Anticipatory**
4.1) Wood for Life project	Requestor: Navajo and Hopi nations, Forest Service, The Nature Conservancy, and National Forest Foundation Outcome: Support and meet tribal fuelwood needs through restoration biomass utilization
4.2) Tribal Forest Protection Act (TFPA)/638 authorities and biomass utilization pilot projects	Requestor: Forest Service, southwestern tribal nations Outcome: Identify best practices to utilize new cross-boundary authorities
4.3) Engage with tribal partners to identify and exchange existing ecological questions or gaps	Requestor: Anticipatory Outcome: Grow tribal partnerships; exchange restoration needs; address science gaps
4.4) Tribal forestry workforce development	Requestor: Indian Forest Management Assessment Team, Intertribal Timber Council Outcome: Tribal Forestry Student Summit; connect workforce needs with emerging tribal graduates

4.1) Wood for Life project. The ERI will continue to work in partnership with the National Forest Foundation, The Nature Conservancy, the Forest Service, and tribal partners to evaluate needs and assess capabilities to formalize and sustain the Wood for Life program. Wood for Life is a tribal fuelwood program that utilizes biomass produced from restoration projects in the 4FRI and Flagstaff Watershed Protection Project footprints. The ERI will support Wood for Life

capacity needs (e.g., grant proposals, communication briefs, after action reviews, etc.) to increase sustainability of the project, as well as help to review and evaluate existing program efforts to inform learning and future processes.

Requestor: Navajo and Hopi nations, Forest Service, The Nature Conservancy, and National Forest Foundation
Outcome: Utilization of restoration biomass to support and meet tribal societal fuelwood needs

Deliverables:

a) Report on progress
b) One (1) presentation with partners on Wood for Life
c) Needs assessment to estimate amount of firewood necessary for "vulnerable and needy" residents using US census data and supplemental community-level questionnaires
d) Proposed TFPA agreement between tribal entity and the US Forest Service to support Wood for Life
e) Facilitation for WFL meetings (rotating chair duties)

4.2) Tribal Forest Protection Act (TFPA)/638 authorities and biomass utilization pilot projects. The ERI will assist tribal partners in scoping biomass utilization opportunities.

Requestor: Forest Service, southwestern tribal nations
Outcome: Best practices to utilize cross-boundary opportunities with newer authorities

Deliverable:

a) Report on progress

4.3) Engage with tribal partners to identify and exchange existing ecological questions or gaps. The ERI has initiated partnerships with the San Carlos Apache and Hualapai tribal nations and will expand those partnerships to exchange restoration information and develop a science needs assessment.

Requestor: Anticipatory
Outcome: Develop and grow tribal partners to exchange restoration science needs, through an assessment with tribal nation partners

Deliverable:

a) Needs assessment of restoration science partnership opportunities

4.4) Tribal forestry workforce development. The ERI is working with national partners to address tribal forestry workforce capacity needs and development opportunities. Action is needed to implement the recommendations of the Indian Forest Management Assessment Team III Workforce Development Strategic Plan. The ERI is the primary organizer for a Tribal Forestry Student Summit to be hosted on the NAU campus. This summit was postponed to a date in fall 2022.

Requestor: Indian Forest Management Assessment Team, Intertribal Timber Council
Outcome: A 2022 Tribal Forestry Student Summit to connect workforce needs with emerging tribal graduates

Deliverable:

a) Report on the 2022 Tribal Student Summit. Planning is ongoing for this hybrid event to occur in October 2022.

Focal Area 5: Science and policy application and interpretation

The ERI mission is to serve diverse audiences with objective science and implementation strategies; this is our strength, and delivering actionable science is a component of every project we design. Activities in Focal Area 5 capture our work to specifically bridge knowledge development to knowledge in practice. In FY22 we will: partner and support federal land managers through Rapid Assessments (RAPs), workshops, and field trips (Focal Area 5.1). For this work plan, we include a focused project and deliverable on our R3 climate adaptation project with the R3 climate coordinator and ecologist (Focal Area 5.2). This effort integrates R3 direction with the USDA climate resources available to provide adaptation strategies to forests in an easy-to-access, defensible product. Additionally, the ERI works closely with Coconino and Kaibab forest restoration implementers to develop and assess appropriate metrics to prescribe and achieve restoration desired outcomes. Work will continue on spatial heterogeneity of forests, and post-treatment forest structural diversity.

With the addition of our forest operations and biomass program and our tribal program, there is an increased need to translate and transfer best available science information to industry and forestry practitioners. An effective way to address a current management or policy issue is through our working papers, white papers, and fact sheets. These publications synthesize research to provide clear, concise explanations of biophysical (working papers) or socio-economic (white papers) restoration topics. Management and policy implications are outlined so that practitioners or elected officials can make quick, informed decisions. Our commitment to putting knowledge into the hands of all affected entities is one of the unique services provided by the ERI and what distinguishes us from traditional academia.

Focal Area 5: Science and policy application and interpretation *Fulfills duties under the Act: 3, 4*	
Action	**Requestor/Anticipatory**
5.1) Provide support to federal land managers with field trips, technical assistance, rapid assessments, learning workshops, and presentations	Requestor: Forest Service leadership, specialists, fire professions, boundary organizations Outcome: Advance and share landscape restoration best practices; transfer of best available science
5.2) Climate adaptation strategy in the southwestern region	Requestor: Forest Service Region 3 Climate Coordination, Ecologist Outcome: Practical climate adaptation strategies for Forest Service practitioners
5.3) Translate and summarize scientific and journal articles for land managers and affected entities	Requestor: Land managers, stakeholders, Southwest Fire Science Consortium, federal agency ID teams, decision and policy makers Outcome: Science synthesis briefs; best available science to practitioners

5.1) Provide support to federal land managers with field trips, technical assistance, rapid assessments, learning workshops, and presentations. The ERI works closely with Forest Service partners at the district, forest, and regional scales to assess science needs and meet science questions with summaries of existing science. To reach broader audiences, we partner with our sister institutes and other boundary organizations to use West-wide webinar and workshop venues for science dissemination. We also facilitate field discussions among Forest Service and other affected entities.

Requestor: Forest Service leadership, specialists, fire professions, boundary organizations
Outcome: Advance and share landscape restoration best practices through rapid technical assessment and tool development of landscape conditions, workshops, field trips, transfer of best available science among diverse geographies and collaborative models

Deliverables:

a) Rapid literature or technical support to Forest Service to meet landscape restoration planning, implementation, and/or monitoring goals
    i. Metrics of restoration success: Continued work with Kaibab and Coconino national forests, 4FRI team, and The Nature Conservancy to co-produce assessments of the best metrics for restoration of desired conditions. This project continues work to quantify and test metrics of restoration success, including tests of tree group definitions in marking and tablet layout units that can be incorporated by implementors (silviculturists, timber sale administrators, and operators) and be used in 4FRI monitoring
    ii. Forest Monitoring and Adaptive Management: The ERI works with the Kaibab National Forest on their monitoring and adaptive management plan. As the new forest plan reaches 8 years, the ERI will develop a project with the Kaibab National Forest to compare monitoring data and assess needs for adaptive management.
    iii. Work with partners to support work toward understanding and predicting regeneration success in post-fire landscapes incorporating climate
b) Up to two (2) field trips to meet science exchange or delivery needs within or among national forests and partners
c) Up to three (3) webinars or workshops in partnership with science-to-manager series, including the Southwest Fire Science Consortium, Rocky Mountain Research Station Science Delivery, or National Forest Foundation
    i. RMRS webinar series — continuation of regeneration workshop, and cross-LEARN outcomes.
    ii. SW FSC webinar series — TBD
    iii. Learning workshops with Kaibab NF, focused on LiDAR training and application

5.2) Climate adaptation strategy in the southwestern region. The ERI with Region 3 and federal research partners will utilize projects from FY20 and FY21 climate adaptation workshops and focal groups to develop practitioner tools for best available climate adaptation strategies.

Requestor: Forest Service Region 3 Climate Coordinator, Ecologist
Outcome: Development and communication of practical climate adaptation strategies for Forest Service practitioners

Deliverables:

a) Provide support to forest-level climate adaptation workshops
b) Provide support to the R3 Climate Adaptation Strategy with appropriate tier-down products, dependent on the complete, peer-reviewed R3 adaptation strategy or Adaptation GTR
c) Translate Southwest vulnerability data to a visually accessible story map (ESRI) or similar tool for a diversity of audiences

5.3) Translate and summarize scientific and journal articles for land managers and affected entities. The ERI develops white papers that address socio-economic policy issues and working papers that summarize science application for land managers. Fact sheets are two-page, brief summaries of peer-reviewed science and Topics in Restoration and Resiliency papers explore a broad restoration topic, like what fire scars tell us about the past and what to expect after restoration, written for a general audience.

Requestor*:* Land managers, stakeholders, Southwest Fire Science Consortium, federal agency ID teams, decision and policy makers
Outcome: Science synthesis briefs for busy practitioners and policy-makers

Deliverables:

a) Three (3) White and/or Working papers, potential topics to include:
    i. Lessons-learned in FWPP
    ii. Human-dimensions or policy influence on managed fires
    iii. Post-fire and storm surge flooding, Museum Fire update
b) Six to eight (6–8) Fact Sheets and/or Topics in Restoration and Resiliency papers

FOCAL AREA 6: Communication and outreach. *Media, community outreach, and information requests.*

The ERI is a recognized expert in the restoration of fire-adapted forests across the western US. Our authorizing legislation details the importance of effectively translating and communicating evidence-based findings to a diverse audience. The ERI recently increased our web delivery capacity with a revised, modern website and a powerful, searchable e-library. We also maintain websites for our collaborative partners (4FRI) and SWERI. In our rapidly changing times and need for real-time communication, our information sharing has expanded into social media outlets like Twitter and Facebook. Through these mediums, the ERI continues to explore and advance innovative communication methods with our growing number of followers. These services have become more needed in the year of Covid-19; this year, we will introduce and test two new online delivery methods of best available science (Focal Area 6.1).

The ERI also serves as an expert for print, radio, internet, and broadcast media. Often, the level of requests to the ERI depend on the local, regional, and national level of discourse on subjects including wildfire, climate change, and landscape sustainability. On average, ERI staff receive approximately 20–30 media requests a year. Our outreach efforts are multi-faceted, with media coverage on the science that informs these critical issues being an important communication piece for shaping the public discourse on wildfire and forest health (Focal Area 6.3).

For more than 20 years, the ERI has served as an objective resource for our land management partners, government agencies, non-government organizations, and our community. Staff from all ERI program areas receive regular requests for information, technical support, and knowledge resources. In FY21, we expect to continue to increase our responses to these requests. In the past five years, we have exceeded information request goals, and as a result we plan to provide at least 40 information request services to all affected entities throughout the fiscal year (Focal Area 6.4).

Focal Area 6 and its deliverables capture the unique services that ERI provides. This suite of outreach and communication services is what distinguishes us from conventional academic units.

Focal Area 6: Communication and outreach *Fulfills duties under the Act: 3*	
Action	**Requestor/Anticipatory**
6.1) Social media and innovative science delivery	Requestor: Anticipatory Outcome: Broaden, grow audience reach using innovative, interactive tools
6.2) Provide website support for the ERI, SWERI, and 4FRI to best meet deliverables	Requestor: All affected entities, 4FRI Stakeholder Group, SWERI Outcome: Science updates and information repository
6.3) Media outreach and engagement	Requestor: All affected entities Outcome: Science synthesis briefs
6.4) Science support, knowledge resource services to federal and non-federal entities	Requestor: Land managers, state forestry agencies, local government, elected officials, and community organizations Outcome: Knowledge to inform action; raise awareness, support for restoration
6.5) Report on FY22 Work Plan activities to SWERI Program Manager	Requestor: SWERI Program Manager Outcome: Final Report

6.1) Social media and innovative science delivery. In FY22, the ERI will develop and test a social media campaign on Twitter/Facebook to increase engagement with our online audience/followers. The goal will be to increase traffic to our website resources, online publications. Additionally, the ERI will expand web delivery to include video media. We will develop a short video on a restoration topic or research area and post it to the website and on social media.

Requestor: Anticipatory
Outcome: Increase audience reach with innovative and interactive social media tools

Deliverables:

a) Media campaign link and Google analytic summaries
b) Video on website and Google analytic summaries

6.2) Provide website support for the ERI, SWERI, and 4FRI to best meet deliverables.

Requestor: All affected entities, 4FRI Stakeholder Group, SWERI
Outcome: Science updates and information repository for all affected entities

Deliverables:

a) Report on actions. Includes website analytic reports on each website's user site visits and engagement metrics.

6.3) Media outreach and engagement. Support the education of the general public through media outreach.

Requestor: All affected entities
Outcome: Science synthesis briefs for busy practitioners and policy-makers

Deliverables:

a) Ten (10) media interviews
b) Ten (10) media articles

6.4) Science support, knowledge resource services to federal and non-federal entities. These activities include filling information requests, technical assistance, field trips, and presentations.

Requestor: Land managers, state forestry agencies, local government, elected officials, and community organizations
Outcome: Knowledge to inform action; raise awareness and support for restoration

Deliverables:

a) A minimum of 40 services or activities

6.5) Report on FY22 Work Plan activities to SWERI Program Manager

***Deliverable*:**

a) FY22 Final Report