Estimating the Economic Impacts of Ecosystem Restoration—Methods and Case Studies

Prepared in cooperation with the U.S. Department of the Interior Natural Resource Damage Assessment and Restoration Program and Office of Policy Analysis and the Bureau of Land Management Socioeconomics Program

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Cover: Riparian planting in the Powell River watershed in Lee County, Virginia. Part of the Lone Mountain NRDAR restoration. Photo credit: Upper Tennessee River Roundtable.

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Executive Summary

Federal investments in ecosystem restoration projects protect Federal trusts, ensure public health and safety, and preserve and enhance essential ecosystem services. These investments also generate business activity and create jobs. It is important for restoration practitioners to be able to quantify the economic impacts of individual restoration projects in order to communicate the contribution of these activities to local and national stakeholders. This report provides a detailed description of the methods used to estimate economic impacts of case study projects and also provides suggestions, lessons learned, and trade-offs between potential analysis methods.

This analysis estimates the economic impacts of a wide variety of ecosystem restoration projects associated with U.S. Department of the Interior (DOI) lands and programs. Specifically, the report provides estimated economic impacts for 21 DOI restoration projects associated with Natural Resource Damage Assessment and Restoration cases and Bureau of Land Management lands. The study indicates that ecosystem restoration projects provide meaningful economic contributions to local economies and to broader regional and national economies, and, based on the case studies, we estimate that between 13 and 32 job-years[4] and between $2.2 and $3.4 million in total economic output[5] are contributed to the U.S. economy for every $1 million invested in ecosystem restoration. These results highlight the magnitude and variability in the economic impacts associated with ecosystem restoration projects and demonstrate how investments in ecosystem restoration support jobs and livelihoods, small businesses, and rural economies. In addition to providing improved information on the economic impacts of restoration, the case studies included with this report highlight DOI restoration efforts and tell personalized stories about each project and the communities that are positively affected by restoration activities. Individual case studies are provided in appendix 1 of this report and are available from an online database at https://www.fort.usgs.gov/economic-impacts-restoration.

[4]Job-years measure the total number of annualized full and part-time jobs accumulated over the duration of a restoration project.

[5]Economic output measures the total value of the production of goods and services supported by project expenditures and is equal to the sum of all intermediate sales (that is, business to business sales) and final demand (that is, sales to consumers).

Introduction

Across the United States, government agencies, nongovernmental organizations, tribes, private industries, scientists, public land managers, and private land owners are teaming up to restore the Nation's ecosystems, thereby restoring wildlife habitat and ecosystem services lost from natural and manmade disasters and revitalizing chronically stressed ecosystems such as forests, prairies, and coastlines. This diverse set of stakeholders pool their financial resources, scientific and technical capacity, regulatory knowledge, heavy equipment and labor resources, and local environmental knowledge to unite as a coordinated system, a "restoration economy" (Baker, 2005). Together, these participants are restoring U.S. lands and waters and, in doing so, are supporting jobs and livelihoods, small businesses, and rural economies. The projects demonstrate that environmental stewardship and economic development can in fact be synergistic, as the process of ecological restoration directly contributes towards socioeconomic well-being (Baker, 2005; Goad and others, 2011; Southwick Associates, 2013; BenDor and others, 2015).

It is important for restoration practitioners to be able to quantify the economic impacts of restoration projects in order to communicate the contribution of these activities to local and national stakeholders. This information can garner support from stakeholders and can be useful for local planning and economic development agencies. Given constrained budgets and competing demands for investment, information on the economic impacts of individual restoration projects helps demonstrate the socioeconomic contributions of projects in addition to the ecological contributions. In many cases, this information can inform public stakeholders and decision makers during planning processes (for example, as part of the National Environmental Policy Act planning process).

There is relatively limited information available on the costs and the associated economic impacts of ecosystem restoration projects, and estimating these impacts is challenging because of the complex composition of the restoration economy. Various studies have estimated the economic impacts of specific restoration projects or programs. For example, Laughland and others (2013) estimate the economic impacts of the U.S. Fish and Wildlife Service's Partners for Fish and Wildlife and Coastal Programs; Hjerpe and Kim (2008), Kim (2010), Southwick Associates and Responsive Management (2013), and the U.S. Department of Agriculture (2015) estimate the economic impacts of U.S. Forest Service fuels reduction projects and the Collaborative Forest Landscape Restoration Program; and The Nature Conservancy (2010) estimates the economic impacts of coastal restoration projects undertaken by the National Oceanic and Atmospheric Administration (NOAA). There are also several studies that estimate the economic impacts of restoration projects within specific States, geographic regions, or the United States (Wagner and Shropshire, 2009; Nielsen-Pincus and Moseley, 2010; Industrial Economics, 2012; Headwaters Economics, 2014; BenDor and others, 2015).

This analysis estimates the economic impacts of a wide variety of ecosystem restoration projects associated with U.S. Department of the Interior (DOI) lands and programs. Specifically, impacts are estimated for 21 DOI restoration projects associated with Natural Resource Damage Assessment and Restoration (NRDAR) cases and Bureau of Land Management (BLM) lands. Of the 21 case studies reviewed for the report, 10 are restoration projects associated with NRDAR case settlements, and 11 are BLM restoration projects. The NRDAR projects are associated with settlement agreements at three sites: the Lone Mountain coal slurry spill site in Virginia, the Crab Orchard National Wildlife Refuge in Illinois, and the California Gulch Superfund site in Colorado. The BLM projects were selected around three focal restoration types: sagebrush and sage-grouse habitat restoration, fuels reduction projects, and post-fire restoration. The analysis was prepared by the U.S. Geological Survey Social and Economic Analysis Branch in cooperation with the Natural Resource Damage Assessment Restoration Program (NRDA Restoration Program), the DOI Office of Policy Analysis, and the BLM Socioeconomics

Program. Individual case studies are provided in appendix 1 of this report and are available from an online database at https://www.fort.usgs.gov/economic-impacts-restoration. The online database of case studies can be sorted and filtered by restoration type, and the database contains additional DOI restoration case studies that were first published in the DOI's economic contributions report for fiscal year 2011 (U.S. Department of the Interior, 2012).

This report provides a detailed description of the methods used to estimate the economic impacts of the DOI and BLM case study projects and also provides suggestions, lessons learned, and trade-offs between potential analysis methods. Practitioners generally use rules of thumb (such as estimates of generic economic impacts expected per $1 million in restoration expenditures) to estimate the economic impacts of restoration projects. A review of the case studies and available literature show that there is substantial variability in the estimated economic impacts of restoration projects; economic impact estimates vary because of differences in restoration types, the diversity and size of the affected economic area, the costs and availability of inputs and labor, and the modeling methods used. Because of this variability, it is suggested that practitioners use caution when using rules of thumb or transferring the results of analyses completed for other projects. This report discusses issues to consider when transferring impact estimates.

It is important to note that the economic impacts estimated in this report are only one piece of the full economic effects of ecosystem restoration. Restoration activities transform degraded ecosystems into restored ecosystems; figure 1 describes the potential economic effects of this transformation. This analysis is focused on the immediate economic impacts (that is, jobs and business activity) generated through expenditures on restoration activities (highlighted in orange). Ecosystem restoration may also result in long-term economic impacts if the restored ecosystems support improved productivity of agriculture and forestry or increase recreation, tourism, or other business activity. Beyond generating economic activity, restored ecosystems provide substantial economic values through improved ecosystem services that directly and indirectly impact human welfare. Economic value is a measure of the benefits enjoyed by individuals or society from the use or existence of a good or service, and is a distinctly different measure than economic impact. Restoration projects can increase economic value by restoring and maintaining important habitat for fish and wildlife species, improving water quality, and reducing fire and flood risk. Several studies have addressed the economic value of ecosystem restoration. Many of these studies were summarized by a blue ribbon panel for estuary economics organized by NOAA (Pendleton, 2010). The NOAA panel set forth guidelines on how to measure the economic value of ecosystem restoration with a specific focus on the economic value of restoring degraded marine and coastal habitat. Hurd (2009) provides a literature review of studies assessing the economic values of watershed restoration projects and an overview of methods that can be used to estimate the economic value of ecosystem restoration.

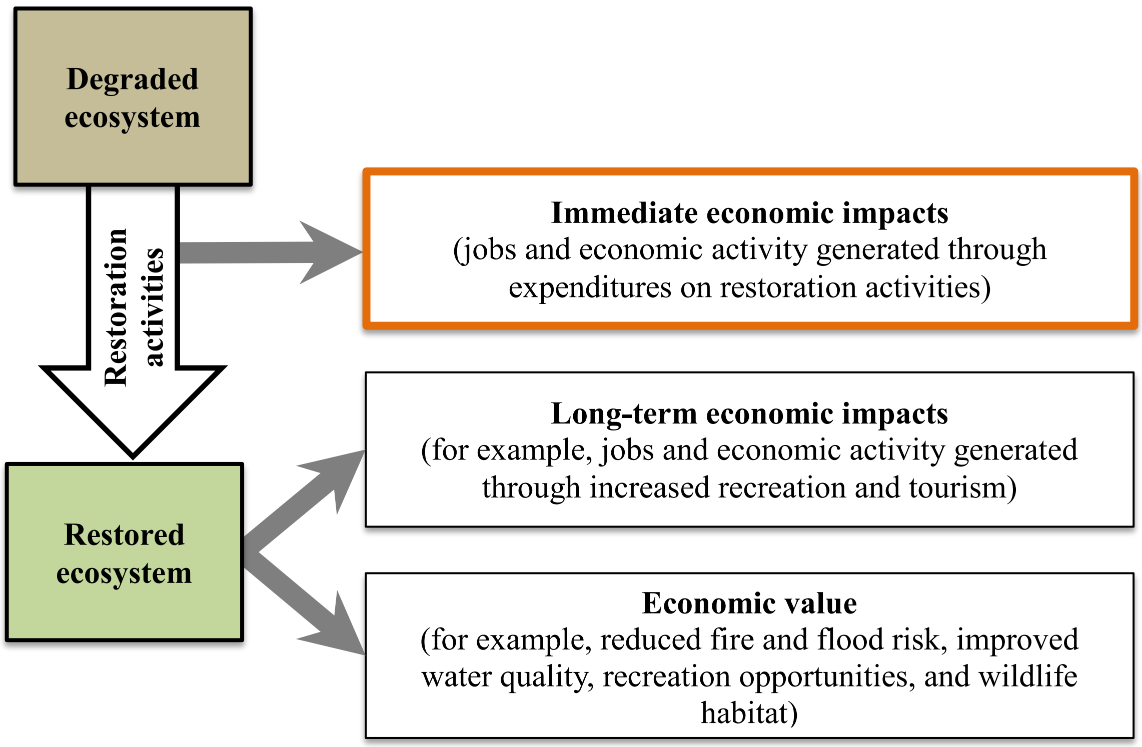

Figure 1. The economic effects of ecosystem restoration.

This report begins with an overview of economic impact analyses and a description of how investments in ecosystem restoration activities generate jobs and business activity. Next, the study methods are described, including selection of case study projects, design and implementation of survey instruments, delineation of economic regions, data compilation, and impact analysis methods. Then, a summary of case study results is provided, including impact per $1 million estimates. Finally, the report concludes with a discussion of lessons learned and ideas on how analysts can approach the challenging problem of tracking the costs and economic impacts of restoration projects. The report also provides comments on the transferability of these and other economic impact results. Full case studies and survey instruments are provided in the appendixes.

Overview of Economic Impact Analyses

Economic impact analyses measure the jobs and economic activity generated through new expenditures in an economy, such as expenditures on ecosystem restoration projects. Economies are complex webs of interacting consumers and producers in which goods produced by one sector of an economy become inputs to another, and the goods produced by that sector can become inputs to yet other sectors. Thus, a change in the final demand for a good or service can generate a ripple effect throughout an economy as businesses and consumers purchase inputs from one another.

In the case of a restoration project, money is directly spent on services such as construction and environmental consulting. This economic activity directly supports jobs and generates income. The firms providing these services purchase materials such as rocks and riprap, monitoring equipment, and seeds to accomplish their work. These are the indirect economic impacts of project expenditures. In order to meet the resultant increase in demand, input suppliers must increase their purchases of inputs from other industries, thus creating additional indirect economic impacts. Employees of directly affected businesses and input suppliers use their disposable incomes to purchase goods and services in the local economy, generating further induced economic impacts of project spending. The sum of the indirect and induced impacts gives the secondary impacts of project spending, and the sum of the direct and secondary impacts gives the total economic impacts of project spending.

Economic input-output models capture these complex interactions between producers and consumers in an economy and describe the secondary impacts of project spending through regional economic multipliers. This study uses multipliers derived from the IMPLAN software and data system (IMPLAN Group, LLC, 2012), a widely used input-output modeling system. The IMPLAN Group LLC collects the underlying data used by the IMPLAN system from several Federal and State sources, including the U.S. Bureau of Economic Analysis, U.S. Bureau of Labor Statistics, and U.S. Census Bureau.

Types of Economic Impacts Measured

This report describes four regional economic impact metrics:

- *Job-years.*—Job-years measure the total number of annualized full and part-time jobs accumulated over the duration of a restoration project. For example, if a project employs a worker for 18 months, this worker would be counted as 1.5 job-years (18 months/12 months in a year). In many cases, workers split their time between multiple projects during a year. For example, an engineer may spend 3 months on a particular restoration project, and a heavy equipment operator may spend 3 weeks on the same project. In these examples, the engineer would be counted as 0.25 job-years (3 months/12 months in a year) and the heavy equipment operator would be counted as 0.06 job-years (3 weeks/52 weeks in a year). Similarly, two engineers who each spend 3 months on a restoration project would total 0.5 job-years (6 months/12 months in a year). Therefore, it is important to note that job-years is a measure of the quantity of employment supported by restoration expenditures, but is not a measure of the number of workers.
- *Labor income.*—Labor income measures the wages and salaries earned through the jobs that are supported by project expenditures. Labor income includes employee wages and payroll benefits, as well as the incomes of sole proprietors.
- *Economic output.*—Economic output measures the total value of the production of goods and services supported by project expenditures and is equal to the sum of all intermediate sales (that is, business to business sales) and final demand (that is, sales to consumers). Economic output is a commonly reported measure of economic impacts, but it is important to understand that this measure totals sales prices at every step of the production chain, and thus double counts the contributions of intermediate goods. For example, consider the restoration activity of planting trees. The economic output associated with this activity would include the cost of planting the trees and the cost of purchasing the trees from a nursery. It would also include the costs of all of the intermediate expenditures required to grow the trees (that is, the costs of seeds, fertilizer, and facilities).
- *Value added.*—Value added is equal to the sum of the values added to a product at each step of the production chain and is thus a measure of the value of the production of goods and services less the cost of intermediate expenditures; that is, value added = economic output – intermediate expenditures. Value added is an equivalent measure to gross domestic product (GDP), which measures the value of the goods and services produced by the U.S. economy each year. Thus, value added is the most appropriate measure to explain how ecosystem restoration projects contribute to GDP. The components of value added are labor income, taxes, profits, and rents.

Considering the example of planting trees, the associated value added would include the labor costs of planting the trees, the profit and rents earned by the firm that plants the trees, the labor required to grow the trees, taxes paid on the production and sale of the trees, and the profit and rents that the nursery earns on the sales of the trees.

Case Study Methods

Restoration projects typically comprise a collection of restoration activities implemented by a variety of private industry contractors, government organizations, and nongovernmental organizations that are orchestrated by a single project manager. Unlike economic activities such as construction, forestry, and engineering, restoration is not well explained by a single sector of the economy; rather, implementing restoration projects requires pulling together companies and organizations working in a wide variety of economic sectors.

In order to estimate the economic impacts of restoration projects, it is necessary to have information on project expenditures and associated economic multipliers. Input-output models are used to estimate economic multipliers and are based on a set of interrelated expenditure profiles for each sector in an economy. An expenditure profile is the set of inputs (such as labor, equipment, and materials) required to produce an output. Economic multipliers are available by economic sector; however, because of the variable and composite nature of restoration projects, there is no “restoration sector” available in common input-output frameworks.

To overcome the lack of economic multipliers for the restoration sector, this study adopted the approach developed by the University of Oregon Ecosystem Workforce Program (EWP) to estimate the economic impacts of forest and watershed restoration in Oregon (Nielsen-Pincus and Moseley, 2010). The EWP developed a survey to elicit and estimate custom expenditure profiles associated with a variety of restoration types and used these expenditure profiles to estimate economic multipliers. This study used the University of Oregon work as an example to design two survey instruments to collect primary data on total project expenditures and develop expenditure profiles for the selected NRDAR and BLM case studies. The detailed expenditure data provided in response to the surveys were used to develop IMPLAN analysis-by-parts models to estimate the economic impacts of project expenditures. This “Case Study Methods” section describes the selection of case studies, the design and implementation of the survey instruments, and the methods used to compile the data and develop IMPLAN analysis-by-parts models to estimate the economic impacts of restoration projects.

Selection of Case Studies

There were two primary goals in selecting case studies:

1. Select a broad range of restoration types and geographic locations in order to highlight the range of DOI and BLM ecosystem restoration projects and observe economic variability across ecosystem restoration projects, and
2. Identify several groupings of similar restoration projects in order to reduce the uncertainty associated with the economic impacts of a select subset of restoration types.

The U.S. Geological Survey (USGS) worked with an advisory group composed of staff from the BLM Socioeconomics Program and the NRDA Restoration Program to select case studies. The advisory group identified 35 potential case studies, and 21 case studies were completed. For a case study to be successfully completed, it was essential that the project manager be engaged and willing to help gather data, provide a connection to the contractors who worked on the project, and tell the story of the restoration project.

Of the 21 selected case studies, 10 are NRDAR restoration projects and 11 are BLM restoration projects. The NRDAR projects are associated with settlement agreements at three sites: the Lone Mountain coal slurry spill site in Virginia, the Crab Orchard National Wildlife Refuge in Illinois, and the California Gulch Superfund site in Colorado. The BLM projects were selected around three focal restoration themes: sagebrush and sage-grouse habitat restoration, fuels reduction projects, and post-fire restoration. The BLM case studies include projects in Idaho, Nevada, New Mexico, Oregon, and Utah. Table 1 provides a list of case study projects. Summaries of each case study are provided in appendix 1, and the case studies are available from an online database at https://www.fort.usgs.gov/economic-impacts-restoration.

Table 1. Restoration case studies identified and surveyed.

[NRDAR, Natural Resource Damage Assessment and Restoration; BLM, Bureau of Land Management]

Case study	Location	Restoration type
NRDAR case studies		
Lone Mountain NRDAR	Virginia	
Freshwater mussel restoration		Aquatic species propagation
Endangered fish restoration		Aquatic species propagation
Tipple site riparian restoration and outdoor classroom		Riparian restoration
Pennington Gap riparian restoration and community park development		Riparian restoration
Acid mine drainage abatement		Acid mine drainage abatement
Crab Orchard National Wildlife Refuge NRDAR	Illinois	
Wastewater Treatment Plant Remediation and Restoration		Hazardous structure removal
Prairie restoration		Prairie restoration
California Gulch Superfund site NRDAR	Colorado	
Arkansas River instream habitat restoration		Instream habitat restoration
Canterbury Tunnel project		Water infrastructure improvement
Dinero Tunnel project		Acid mine drainage abatement
BLM case studies		
Color Country District	Utah	
South Canyon restoration		Watershed and sagebrush restoration
Duncan Creek restoration		Watershed and sagebrush restoration
South Beaver restoration		Watershed and sagebrush restoration
Upper Kanab Creek restoration		Watershed and sagebrush restoration
Southern Nevada Public Land Management Act	Nevada	
Steptoe Valley weed inventory, education, and treatment		Invasive weed management
Pioche/Caselton wildland-urban interface project		Fuels reduction
Burley Landscape sage-grouse habitat restoration	Idaho	Sagebrush restoration
Twin Falls District sagebrush restoration	Idaho	Sagebrush restoration
Post-wildfire restoration	Oregon	
Miller Homestead post-fire restoration		Post-fire restoration
Long Draw post-fire restoration		Post-fire restoration
Zuni Mountains forest restoration project	New Mexico	Fuels reduction

Survey Design and Implementation

Two survey instruments were developed to collect project data: the project summary survey and the expenditure survey.[6] The project summary survey and the expenditure survey are provided in appendixes 2 and 3, respectively. This dual-survey design was based on the assumptions that (1) a restoration project is a collection of restoration actions and (2) each restoration project is led by a project manager who completes some restoration actions in-house and contracts the remaining restoration actions to other firms and organizations. Each restoration action—such as planning, design work, site preparation, and planting—is a distinct component of a project.

The Project Summary Survey

The project summary survey was completed by the project manager. This survey collects two sets of data: (1) descriptive and categorical information about the restoration project and (2) information about the total costs and composition of the restoration project. The project summary survey was implemented online using Key Survey™ software. The online version of the software allows for question branching and skipping.

The purpose of the first set of questions was to collect background information that is useful in classifying and describing each restoration project. These questions, which were developed by restoration practitioners associated with the NRDA Restoration Program, address the type of injury to the land, the focus of the restoration, the restoration actions that took place, land ownership and realty changes associated with the restoration project, the type of restored land cover, the types of supported species, and any affected cultural or tribal resources.

The purpose of the second set of questions was to collect the cost and project composition information needed to implement the expenditure survey. The project manager was asked to provide the total project cost broken down into in-house expenditures and contracted expenditures. Project managers were also asked to provide contractor contact information and to identify the restoration actions implemented by each contractor.

The Expenditure Survey

The purpose of the expenditure survey was to gather the information necessary to develop project-level expenditure profiles. The survey asked each project manager and contractor to break down their expenditures into detailed labor, nonlabor, and subcontracting expenditures. Project managers were asked to complete the expenditure survey for each restoration action implemented in-house and contractors were asked to complete the expenditure survey for each of the restoration actions that they implemented, as identified in the project summary survey. Expenditures for each restoration action were reported as a percentage of total expenditures as opposed to dollar values; this method had the advantage of allowing respondents to estimate their expenditure breakdowns if they were unable to calculate the exact expenditure breakdowns for the project. In order to estimate local expenditures and impacts, respondents were asked to identify the percentage of each expenditure that was spent within the local area. The local area was defined for each project and provided in the survey instructions. Details about how local areas were selected are included in the "Economic Regions" section.

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[6]These surveys were developed by the USGS in collaboration with the NRDA Restoration Program, the BLM, and the U.S. Forest Service; they were approved by the U.S. Office of Management and Budget (1028-0107).

Each contractor was contacted by phone and, after the project and survey were explained, asked if they were willing to participate in the expenditure survey. Willing participants were emailed an Excel-based version of the survey. Survey participants were encouraged to call or email if they had any questions about the survey. We utilized the data collection methods outlined in Dillman (2011), following up with each participant up to three times. A total of 126 contractors and project managers were identified as working on case study projects, and successful contact was made with 86 of these potential expenditure survey respondents. Of the 86 potential respondents, 71 agreed to participate in the survey, and 53 of those 71 successfully completed the survey, giving an overall response rate of 42 percent for the expenditure survey.

Economic Regions

To estimate economic multipliers, it was necessary to determine the extent of the economic regions to include in the analysis. Economic multipliers capture the circulation of money within an economic region. If the services and supplies for a project cannot be purchased within the local economy, they will be purchased outside of the local economy. When money leaves the local economy, it is "leaked" from the model and no longer generates local economic impacts. This means that the size and the economic diversity of the local area matters; that is, the larger and more diverse a local area is, the less money will leak from the local economy. Thus, the selection of the local area is an important variable in determining the economic impacts of a project.

The NRDA Restoration Program and the BLM Socioeconomics Program are interested in both the local impacts of restoration projects (that is, jobs and business activity generated in the communities directly surrounding the restoration site) and the broader impacts that restoration project expenditures generate in the national and Western States economies. To address these interests, two economic regions were defined for each case study project: (1) the local region and (2) a broader national region for NRDAR projects or the Western States[7] region for BLM projects.

The local region for both the NRDAR and BLM case studies was defined as a set of counties surrounding the project site. The goal in selecting the local region was to capture all of the counties that compose a cohesive economic region that includes the communities within a reasonable commuting distance of the site. The local regions were defined based on the Forest Service labor market protocol for delineation of economic impact analysis areas (M.F. Retzlaff, U.S. Forest Service, unpublished data, 2010).

Data Compilation

For each case study, it was necessary to compile data from one project summary survey and a collection of expenditure surveys. The goal in compiling the data was to develop a single project-level expenditure profile for each case study. Table 2 provides an example project-level expenditure profile for the Duncan Creek case study in BLM's Color Country. The expenditure profile gives detailed data on combined project expenditures for labor, equipment rental and repair, overhead and administration, travel costs, materials, and subcontractors. Expenditures were estimated based on the total cost data provided in the project summary surveys and the restoration activity splits provided in the expenditure surveys.

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[7]The BLM Western States are Arizona, California, Colorado, Idaho, Kansas, Montana, Nebraska, Nevada, New Mexico, North Dakota, Oklahoma, Oregon, South Dakota, Texas, Utah, Washington, and Wyoming.

Table 2. Example project-level expenditure profile—from the Duncan Creek case study (Bureau of Land Management's Color Country).

Expenditure category	Total project expenditures[1]	Local project expenditures[2]
Employee compensation	$374,957	$187,126
Proprietors' income	$88,695	$0
Equipment rental/leasing/daily use rates	$16,460	$4,115
Equipment maintenance and repair	$74,948	$39,904
Overhead/administration	$112,082	$8,110
Travel per diem	$40,870	$37,400
Travel—car/truck rental	$6,551	$3,505
Travel—gas (retail)	$62,888	$49,889
Materials—general retail merchandise (retail)	$34,223	$17,325
Materials—gasoline (retail)	$40,806	$21,834
Materials—seeds (wholesale)	$85,478	$0
Materials—seeds (direct)	$42,739	$0
Materials—communications equipment (retail)	$7,664	$8,202
Subcontracting—aerial seeding	$20,777	$0
Total	$1,009,138	$377,410

[1]Total project expenditures by expenditure category are estimated and reflect the combined expenditures for the project manager and all contracted firms. For example, the value listed for employee compensation reflects the estimated total wages and benefits paid to private and public employees who worked on the Color Country Duncan Creek restoration project. Project expenditures by expenditure category are net of estimated profits, taxes, and rents.

[2]Local project expenditures by expenditure category reflect the estimated amount of project spending that was made within the local area directly surrounding the project site. An estimated $377,410 of the Color Country Duncan Creek project expenditures were made within the local area surrounding the project site (Beaver, Garfield, Iron, Kane, and Washington Counties in Utah). Local project expenditures include indirect local expenditures made by local and nonlocal contractors (such as gas, equipment rental, travel expenses, and wages paid to local workers hired by nonlocal contractors).

The first step in developing project-level expenditure profiles was to estimate each contractor's expenditures for each restoration activity based on the total cost data provided in the project summary surveys and the restoration activity splits provided in the expenditure surveys. Next, activity expenditures were broken down into expenditures for labor, equipment rental and repair, overhead and administration, travel costs, materials, and subcontracting using the detailed expenditure splits provided in the expenditure surveys. Finally, expenditures were summed across each contractor and activity in order to estimate an overall project-level expenditure profile. Local expenditures for each category were estimated using the percentages provided in the expenditure surveys. All expenditures were inflated to 2014 dollars using U.S. Bureau of Economic Analysis output deflators.

Impact Analysis

Economic impacts of project expenditures were estimated by applying project-level expenditure profiles to the IMPLAN software and data system.[8] The IMPLAN v3.0 2012 National Data Set (IMPLAN Group, LLC, 2012) was used for this study. County-level IMPLAN models were used to estimate the local impacts for all of the case studies, the National IMPLAN model was used to estimate national-level impacts for NRDAR case studies, and a State-level model composed of the Western States[9] was used to estimate Western State-level impacts for BLM case studies. All impacts were estimated in 2014 dollars.

IMPLAN Analysis-by-Parts Method

The IMPLAN model and data set organizes an economy into a set of sectors. Each IMPLAN sector has a representative expenditure profile for a set of similar industries based on the North American Industry Classification System (NAICS). Typically, an impact analysis will estimate the impacts of expenditures that are well explained by an IMPLAN sector. However, there is no IMPLAN sector that describes the diverse ecosystem restoration industry. Thus, the expenditure profiles that were estimated based on the primary data collection were used to develop analysis-by-parts models. These models can then be used to estimate the economic impacts of each case study project.

Analysis-by-parts is a modeling approach that can be used to custom build an industry. In an analysis-by-parts, rather than directly applying expenditures to an IMPLAN sector, the labor expenditures and the goods and services that must be purchased in order to complete the restoration activity are specified. By specifying the specific goods and services purchased, the IMPLAN model can be used to estimate the indirect and induced effects of project purchases and labor expenditures (that is, the secondary effects). The primary data collected through the surveys were used to estimate the direct economic impacts of projects.

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[8]To estimate project impacts, project expenditures net of profits, taxes, and rents should be applied to the IMPLAN model. However, the expenditure survey does not explicitly ask respondents about the percentage of project expenditures that go toward profits, taxes, and rents. Therefore, project expenditure estimates needed to be adjusted to remove profits, taxes, and rents from intermediate expenditure estimates. To make this adjustment, direct value added was estimated because profits, taxes, and rents are components of value added (that is, value added = profits, taxes, and rents + labor income). To estimate value added, a “best-fit” IMPLAN sector was selected to represent each restoration action (appendix 4), and direct value added was estimated for each action by multiplying total expenditures for the action (equivalent to direct output) by the national value added per output ratio for the best-fit sector. Profits, taxes, and rents could then be estimated as the difference between value added and labor income estimates (that is, profits, taxes, and rents = value added – labor income). Finally, estimated profits, taxes, and rents were proportionately removed from all intermediate expenditure estimates.

[9]The BLM Western States include Arizona, California, Colorado, Idaho, Kansas, Montana, Nebraska, Nevada, New Mexico, North Dakota, Oklahoma, Oregon, South Dakota, Texas, Utah, Washington, and Wyoming.

Direct Effects

Direct effects for each economic impact metric were estimated as follows:

- *Direct output.*—Direct output is equal to the sum of total expenditures for each restoration activity. Direct outputs were estimated directly from the primary expenditure data collected with the project summary and project expenditure surveys.
- *Direct labor income.*—Direct labor income for each activity was estimated by multiplying the total activity expenditure by the labor split percentage provided in the expenditure surveys. Direct labor income was further split into proprietors' income and employee compensation. To estimate the split between proprietors' income and employee compensation, each restoration activity was matched to a best-fit IMPLAN sector[10], and employee compensation was estimated by multiplying direct labor income by the national employee compensation per labor income ratio for the best-fit sector[11] as defined in appendix 4.
- *Direct job-years.*—Direct job-years were estimated by first estimating full-time equivalents (FTEs). The FTEs per activity were calculated as direct labor income divided by average wage rate (provided in the expenditure survey) divided by 2,080 hours (the number of work hours in a full-time work year). IMPLAN reports jobs, which include both full- and part-time jobs, rather than FTEs. A table that provides jobs per FTE by sector is available on the IMPLAN Website (http://www.IMPLAN.com). For each activity, the estimated FTEs were converted to job-years by multiplying by the jobs per FTE ratio for the best-fit IMPLAN sector.
- *Direct value added.*—Direct value added was estimated for each activity by multiplying direct output estimates for the activity by the value added per output ratio for the best-fit sector from the national IMPLAN model.[12]

Secondary Effects

To estimate secondary effects, the compiled project-level expenditures were entered in IMPLAN as a series of labor income, industry, and commodity changes. For local models, only dollars spent in the local area were entered into the IMPLAN model; therefore, local purchase percentages were set to 100 percent for most expenditures.

For expenditures on materials, survey respondents were asked to indicate if goods were purchased from a retailer, a wholesaler, or directly from the manufacturer. Retail and wholesale purchases were margined using industry margins.[13] Local purchase percentages for retail and wholesale

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[10]A list of "best-fit" IMPLAN sectors for restoration actions is in appendix 4.
[11]For BLM case studies, ratios from the Western States model were used.
[12]For BLM case studies, ratios from the Western States model were used.
[13]When a contracting firm purchases materials for a project, they can purchase the materials either from a retail or wholesale supplier or directly from the manufacturer. If supplies are purchased directly from the manufacturer, 100 percent of the purchase price goes to that manufacturing sector. If the supplies are purchased from a wholesaler or retailer, it is necessary to margin the purchase so that the sale price is distributed between the retail, wholesale, transportation, and producing sectors. For example, 100 percent of the purchase price for grass seed purchased directly from the farmer would go to the farming sector. However, for grass seed purchased from a retail store, about 60 percent of the purchase price would go to the farming sector, 30 percent to the retail sector, 4 percent to the wholesale trade sector, and 5 percent to the truck transportation sector.

margins were set to IMPLAN Social Accounting Matrix (SAM) model values[14] with the local purchase percentage for the retail or wholesale portion of the margins set to 100 percent. Appendix 5 provides a crosswalk table linking expenditure categories to IMPLAN sectors. Because the expenditures entered into the IMPLAN model represent the first round of indirect spending, the total impacts estimated in the IMPLAN model actually represent the secondary effects of project expenditures.

Addressing Missing Data and Subcontractors

All contractors who were directly hired to work on a restoration project were asked to complete the expenditure survey for each of the restoration activities in which they participated. If contractors subcontracted out a portion of the work, the contractors were asked to detail the amount and nature of subcontracted expenditures. Expenditures for activities performed by subcontractors and by contractors who did not return the expenditure survey were matched to best-fit IMPLAN sectors (as defined in appendix 4). These expenditures were run in IMPLAN as industry change activities separately from the analysis-by-parts.

Case Study Results

Project expenditures and associated economic impacts were estimated for 21 case study projects. This section provides a summary of local economic impact estimates as well as economic impacts at the national or Western States level. Individual case studies are in appendix 1 of this report and are available from an online database at https://www.fort.usgs.gov/economic-impacts-restoration. The online database of case studies can be sorted and filtered by restoration type, and the database contains additional DOI restoration case studies that were first published in DOI's economic contributions report for fiscal year 2011 (U.S. Department of the Interior, 2012).

Summary of Local Economic Impacts

Table 3 provides a summary of estimated local project expenditures and associated local economic impacts for each of the 21 case studies. For this analysis, local areas were defined by considering only those counties that fell within a reasonable commuting distance of each project site. (The "Economic Regions" section of this paper provides details on how local areas were defined.). The impact estimates reported in table 3 represent only those jobs and economic activity supported by expenditures that occurred within the local area economy.

Local impacts vary dramatically because they are dependent on the percentage of expenditures spent locally and on the structure, size, and diversity of the local economy. Table 3 gives the local area definition and the estimated amount and percentage of project expenditures that were spent within the local area for each of the case studies. For many projects, contractors and input suppliers within the local economy were used when possible; however, smaller, less diverse economies usually do not have all of the industries required for a project, and restoration projects may require specialized service providers that are not available locally. Furthermore, many government contracts must go to the lowest qualified bidder and these contractors may be located outside of the local area. Direct project expenditures that were spent outside of the local area did not generate any local economic activity. Information from the expenditure surveys was used to estimate indirect local expenditures made by

[14]SAM model values provide estimates of the portion of the demand for a commodity that is met by local supply. SAM model values are included in the IMPLAN Social Accounting Matrix data.

nonlocal contractors (such as gas, equipment rental, travel expenses, and wages paid to local workers hired by nonlocal contractors).

Secondary economic impacts are also affected by the structure, size, and diversity of the local economy. Indirect and induced effects are generated through the ripple effect of input suppliers and workers spending money within the local economy. When input suppliers and workers purchase goods and services from outside the local area, the expenditures leak from the local economy. Thus, the amount of secondary economic activity generated by a project is affected by the economic diversity of the local area; that is, the more urban or diverse a local area is, the less economic activity will leak. Projects with relatively small local area definitions, especially those in rural areas, will typically generate less local economic activity than similar projects located in larger, more economically diverse locations. Because of the large variability in local economic impacts, we do not suggest that these impacts be used to transfer impact estimates to other restoration projects.

Table 3. Summary of local economic impacts for case study projects.

[NRDAR, Natural Resource Damage Assessment and Restoration; Ky., Kentucky; Tenn., Tennessee; Va., Virginia; Ill., Illinois; Colo., Colorado; BLM, Bureau of Land Management; Nev., Nevada; Oreg., Oregon; N. Mex., New Mexico]

Project	Local area	Restoration type	Project period (start year–end year)	Local project expenditures (2014 dollars) [percentage of total project expenditures]	Local job-years	Local labor income (2014 dollars)	Local value added (2014 dollars)	Local economic output (2014 dollars)
NRDAR case studies								
Lone Mountain NRDAR—freshwater mussel restoration	Counties in Ky., Tenn., and Va. within a 60-mile radius of the project site	Aquatic species propagation	2004–2012	$30,000 [4 percent]	0.0	$0	$0	$30,000
Lone Mountain NRDAR—endangered fish restoration	Counties in Ky., Tenn., and Va. within a 60-mile radius of the project site	Aquatic species propagation	2004–2014	$1,000 [<1 percent]	0.0	$0	$0	$1,000
Lone Mountain NRDAR—Tipple site riparian restoration and outdoor classroom	Counties in Ky., Tenn., and Va. within a 60-mile radius of the project site	Riparian restoration	2011–2014	$109,000 [65 percent]	1.7	$62,000	$88,000	$169,000
Lone Mountain NRDAR—Pennington Gap riparian restoration and community park development	Counties in Ky., Tenn., and Va. within a 60-mile radius of the project site	Riparian restoration	2011–2014	$47,000 [51 percent]	0.9	$27,000	$34,000	$86,000
Lone Mountain NRDAR—acid mine drainage abatement	Counties in Ky., Tenn., and Va. within a 60-mile radius of the project site	Acid mine drainage abatement	2010–2011	$290,000 [62 percent]	2.3	$118,000	$175,000	$427,000

Table 3. Summary of local economic impacts for case study projects.—Continued

[NRDAR, Natural Resource Damage Assessment and Restoration; Ky., Kentucky; Tenn., Tennessee; Va., Virginia; Ill., Illinois; Colo., Colorado; BLM, Bureau of Land Management; Nev., Nevada; Oreg., Oregon; N. Mex., New Mexico]

Project	Local area	Restoration type	Project period (start year–end year)	Local project expenditures (2014 dollars) [percentage of total project expenditures]	Local job-years	Local labor income (2014 dollars)	Local value added (2014 dollars)	Local economic output (2014 dollars)
Crab Orchard NRDAR—wastewater treatment plant remediation and restoration	Franklin, Jackson, Union, and Williamson Counties, Ill.	Hazardous structure removal	1991–2009	$3,162,000 [35 percent]	32.4	$1,791,000	$3,002,000	$4,737,000
Crab Orchard NRDAR—prairie restoration	Franklin, Jackson, Union, and Williamson Counties, Ill.	Prairie restoration	2014–2014	$17,000 [41 percent]	0.5	$17,000	$18,000	$28,000
California Gulch NRDAR—Arkansas River instream habitat restoration	Chaffee, Lake, and Summit Counties, Colo.	Instream habitat restoration	2010–2014	$1,763,000 [54 percent]	25.0	$1,268,000	$1,667,000	$3,261,000
California Gulch NRDAR—Canterbury Tunnel	Chaffee, Lake, and Summit Counties, Colo.	Water infrastructure improvement	2012–2012	$867,000 [52 percent]	8.6	$516,000	$769,000	$1,702,000
California Gulch NRDAR—Dinero Tunnel	Chaffee, Lake, and Summit Counties, Colo.	Acid mine drainage abatement	2006–2014	$118,000 [9 percent]	2.0	$117,000	$127,000	$206,000

Table 3. Summary of local economic impacts for case study projects.—Continued

[NRDAR, Natural Resource Damage Assessment and Restoration; Ky., Kentucky; Tenn., Tennessee; Va., Virginia; Ill., Illinois; Colo., Colorado; BLM, Bureau of Land Management; Nev., Nevada; Oreg., Oregon; N. Mex., New Mexico]

Project	Local area	Restoration type	Project period (start year–end year)	Local project expenditures (2014 dollars) [percentage of total project expenditures]	Local job-years	Local labor income (2014 dollars)	Local value added (2014 dollars)	Local economic output (2014 dollars)
BLM case studies								
Color Country—South Canyon restoration	Beaver, Garfield, Iron, Kane, and Washington Counties, Utah	Watershed and sagebrush restoration	2010–2013	$1,194,000 [34 percent]	14.7	$855,000	$1,202,000	$2,029,000
Color Country—Duncan Creek restoration	Beaver, Garfield, Iron, Kane, and Washington Counties, Utah	Watershed and sagebrush restoration	2012–2012	$387,000 [37 percent]	5.0	$284,000	$367,000	$692,000
Color Country—South Beaver restoration	Beaver, Garfield, Iron, Kane, and Washington Counties, Utah	Watershed and sagebrush restoration	2006–2011	$2,505,000 [72 percent]	37.2	$1,993,000	$2,536,000	$4,243,000
Color Country—Upper Kanab Creek restoration	Beaver, Garfield, Iron, Kane, and Washington Counties, Utah	Watershed and sagebrush restoration	2010–2013	$391,000 [38 percent]	5.0	$280,000	$359,000	$666,000
Southern Nevada Public Land Management Act—Steptoe Valley weeds	Lincoln, Nye, and White Pine Counties, Nev.	Invasive weed management	2008–2012	$605,000 [95 percent]	20.4	$678,000	$632,000	$1,119,000
Southern Nevada Public Land Management Act—Pioche/Caselton	Lincoln, Nye, and White Pine Counties, Nev.	Fuels reduction	2012–2013	$72,000 [15 percent]	1.0	$79,000	$75,000	$119,000

Table 3. Summary of local economic impacts for case study projects.—Continued

[NRDAR, Natural Resource Damage Assessment and Restoration; Ky., Kentucky; Tenn., Tennessee; Va., Virginia; Ill., Illinois; Colo., Colorado; BLM, Bureau of Land Management; Nev., Nevada; Oreg., Oregon; N. Mex., New Mexico]

Project	Local area	Restoration type	Project period (start year–end year)	Local project expenditures (2014 dollars) [percentage of total project expenditures]	Local job-years	Local labor income (2014 dollars)	Local value added (2014 dollars)	Local economic output (2014 dollars)
Burley Landscape sage-grouse habitat restoration	Cassia, Minidoka, and Twin Falls Counties, Idaho	Sage-grouse habitat restoration	2008–2014	$255,000 [18 percent]	7.6	$301,000	$312,000	$450,000
Twin Falls District sagebrush restoration	Elmore, Gooding, Lincoln, Minidoka, Owyhee, and Twin Falls Counties, Idaho	Sagebrush restoration	2009–2014	$792,000 [54 percent]	19.1	$660,000	$543,000	$1,172,000
Post-wildfire restoration—Miller Homestead fire	Grant, Harney, and Malheur Counties, Oreg.	Post-fire restoration	2013–2014	$1,002,000 [40 percent]	19.2	$709,000	$768,000	$1,681,000
Post-wildfire restoration—Long Draw fire	Canyon and Payette Counties, Idaho; and Malheur County, Oreg.	Post-fire restoration	2013–2014	$3,800,000 [69 percent]	46.6	$2,262,000	$2,664,000	$6,248,000
Zuni Mountains forest restoration	Cibola County, N. Mex.	Fuels reduction	2013–2014	$63,000 [72 percent]	1.5	$60,000	$23,000	$79,000

Summary of National/Western States Impacts

Restoration projects support jobs and business activity beyond the local communities that directly surround restoration sites. This section presents the broader impacts that restoration project expenditures generated in the national and Western States economies. Table 4 provides a summary of total project expenditures and associated economic impact estimates at the national level for NRDAR case studies and at the Western States level for BLM case studies.

Total project expenditures vary substantially between restoration projects, ranging from projects that cost less than $100,000 to projects that cost several millions of dollars. To allow for comparisons between economic impacts, and to aid in the possible transfer of these impact estimates to other similar restoration projects, table 4 provides impact estimates normalized per $1 million of project expenditures. Several variables might influence the economic impact per $1 million estimates. For example, the split between labor and nonlabor expenditures for a project plays a large role in job and income impacts. Projects that are labor intensive, such as projects requiring hand labor or with large percentages of planning and engineering expenditures, will have the greatest job and income impacts. Conversely, projects that have large percentages of equipment or materials expenditures will typically have relatively lower total job and income impacts, though they may support relatively higher average incomes per worker. Value added and economic output estimates will be sensitive to the amount of processing and the labor required to produce the equipment and materials used in a project. For example, a purchase of quarried rocks, a relatively raw good, will likely result in smaller value added and economic output impacts compared to the purchase of a cement culvert, a good that requires both quarrying and manufacturing.

Job-years per $1 million estimates for the 21 case studies vary from a low of 12.9 job-years per $1 million for the California Gulch NRDAR Canterbury Tunnel project to a high of 32.1 job-years per $1 million for the Southern Nevada Public Land Management Act Steptoe Valley invasive weed management project. The differences in estimated job-years per $1 million are primarily dependent on the split between labor and nonlabor expenditures. Job estimates are also very dependent on the average hourly wage rates for each project activity.

There is relatively less variation across the case study projects for the per $1 million estimates for labor income, value added, and economic output. Per $1 million labor income estimates range from $802,000 for the Miller Homestead post-wildfire restoration project to $1,500,000 for the Lone Mountain NRDAR endangered fish restoration project. Like job-year estimates, labor income estimates are sensitive to the split between labor and nonlabor project expenditures. Per $1 million value added estimates range from $1,200,000 for the Long Draw and Miller Homestead post-wildfire restoration projects to $1,800,000 for the Lone Mountain NRDAR endangered fish restoration project and the Crab Orchard NRDAR prairie restoration project. Per $1 million economic output estimates range from $2,200,000 for the Color Country South Beaver watershed and sagebrush restoration project to $3,400,000 for the Crab Orchard NRDAR prairie restoration project.

Table 4. Summary of national/Western States economic impacts for case study projects.
[M, million; NRDAR, Natural Resource Damage Assessment and Restoration; K, thousand; BLM, Bureau of Land Management]

Project	Location	Restoration type	Project period (start year–end year)	Total project expenditure (2014 dollars)	Job-years (Normalized per $1M of project expenditures)	Labor income (2014 dollars) (Normalized per $1M of project expenditures)	Value added (2014 dollars) (Normalized per $1M of project expenditures)	Economic output (2014 dollars) (Normalized per $1M of project expenditures)
National economic impacts for NRDAR case studies								
Lone Mountain NRDAR—freshwater mussel restoration	Virginia	Aquatic species propagation	2004–2012	$697,000	21.2 (30.4 per $1M)	$962,000 ($1.4M per $1M)	$1,191,000 ($1.7M per $1M)	$1,948,000 ($2.8M per $1M)
Lone Mountain NRDAR—endangered fish restoration	Virginia	Aquatic species propagation	2004–2014	$177,000	5.6 (31.6 per $1M)	$259,000 ($1.5M per $1M)	$313,000 ($1.8M per $1M)	$529,000 ($3.0M per $1M)
Lone Mountain NRDAR—Tipple site riparian restoration and outdoor classroom	Virginia	Riparian restoration	2011–2014	$169,000	3.0 (17.8 per $1M)	$164,000 ($970K per $1M)	$244,000 ($1.4M per $1M)	$421,000 ($2.5M per $1M)
Lone Mountain NRDAR—Pennington Gap riparian restoration and community park development	Virginia	Riparian restoration	2011–2014	$93,000	1.6 (17.2 per $1M)	$95,000 ($1.0M per $1M)	$138,000 ($1.5M per $1M)	$239,000 ($2.6M per $1M)
Lone Mountain NRDAR—acid mine drainage abatement	Virginia	Acid mine drainage abatement	2010–2011	$465,000	7.1 (15.3 per $1M)	$455,000 ($978K per $1M)	$655,000 ($1.4M per $1M)	$1,236,000 ($2.7M per $1M)

Table 4. Summary of national/Western States economic impacts for case study projects.—Continued

[M, million; NRDAR, Natural Resource Damage Assessment and Restoration; K, thousand; BLM, Bureau of Land Management]

Project	Location	Restoration type	Project period (start year–end year)	Total project expenditure (2014 dollars)	Job-years (Normalized per $1M of project expenditures)	Labor income (2014 dollars) (Normalized per $1M of project expenditures)	Value added (2014 dollars) (Normalized per $1M of project expenditures)	Economic output (2014 dollars) (Normalized per $1M of project expenditures)
Crab Orchard NRDAR—wastewater treatment plant remediation and restoration	Illinois	Hazardous structure removal	1991–2009	$9,101,000	139.4 (15.3 per $1M)	$8,789,000 ($966K per $1M)	$13,242,000 ($1.5M per $1M)	$21,781,000 ($2.4M per $1M)
Crab Orchard NRDAR Program—prairie restoration	Illinois	Prairie restoration	2014–2014	$42,000	0.9 (21.4 per $1M)	$46,000 ($1.1M per $1M)	$75,000 ($1.8M per $1M)	$143,000 ($3.4M per $1M)
California Gulch NRDAR Program—Arkansas River instream habitat restoration	Colorado	Instream habitat restoration	2010–2014	$3,244,000	49.5 (15.3 per $1M)	$3,119,000 ($961K per $1M)	$4,600,000 ($1.4M per $1M)	$9,060,000 ($2.8M per $1M)
California Gulch NRDAR Program—Canterbury Tunnel	Colorado	Water infrastructure improvement	2012–2012	$1,674,000	21.6 (12.9 per $1M)	$1,461,000 ($873K per $1M)	$2,325,000 ($1.4M per $1M)	$4,462,000 ($2.7M per $1M)
California Gulch NRDAR Program— Dinero Tunnel	Colorado	Acid mine drainage abatement	2006–2014	$1,294,000	24.3 (18.8 per $1M)	$1,472,000 ($1.1M per $1M)	$1,988,000 ($1.5M per $1M)	$3,767,000 ($2.9M per $1M)
Western States economic impacts for BLM case studies								
Color Country—South Canyon restoration	Utah	Watershed and sagebrush restoration	2010–2013	$3,546,000	59.8 (16.9 per $1M)	$3,616,000 ($1.0M per $1M)	$4,629,000 ($1.3M per $1M)	$8,755,000 ($2.5M per $1M)

Table 4. Summary of national/Western States economic impacts for case study projects.—Continued

[M, million; NRDAR, Natural Resource Damage Assessment and Restoration; K, thousand; BLM, Bureau of Land Management]

Project	Location	Restoration type	Project period (start year–end year)	Total project expenditure (2014 dollars)	Job-years (Normalized per $1M of project expenditures)	Labor income (2014 dollars) (Normalized per $1M of project expenditures)	Value added (2014 dollars) (Normalized per $1M of project expenditures)	Economic output (2014 dollars) (Normalized per $1M of project expenditures)
Color Country—Duncan Creek restoration	Utah	Watershed and sagebrush restoration	2012–2012	$1,039,000	18.4 (17.7 per $1M)	$1,051,000 ($1.0M per $1M)	$1,372,000 ($1.3M per $1M)	$2,624,000 ($2.5M per $1M)
Color Country—South Beaver restoration	Utah	Watershed and sagebrush restoration	2006–2011	$3,491,000	59.4 (17.0 per $1M)	$3,508,000 ($1.0M per $1M)	$4,635,000 ($1.3M per $1M)	$7,838,000 ($2.2M per $1M)
Color Country—Upper Kanab Creek restoration	Utah	Watershed and sagebrush restoration	2010–2013	$1,026,000	18.1 (17.6 per $1M)	$1,103,000 ($1.1M per $1M)	$1,344,000 ($1.3M per $1M)	$2,587,000 ($2.5M per $1M)
Southern Nevada Public Land Management Act—Steptoe Valley weeds	Nevada	Invasive weed management	2008–2012	$635,000	20.4 (32.1 per $1M)	$781,000 ($1.2M per $1M)	$889,000 ($1.4M per $1M)	$1,483,000 ($2.3M per $1M)
Southern Nevada Public Land Management Act—Pioche/Caselton	Nevada	Fuels reduction	2012–2013	$496,000	9.7 (19.6 per $1M)	$572,000 ($1.2M per $1M)	$688,000 ($1.4M per $1M)	$1,198,000 ($2.4M per $1M)
Burley Landscape sage-grouse habitat restoration	Idaho	Sage-grouse habitat restoration	2008–2014	$1,395,000	41.8 (30.0 per $1M)	$1,605,000 ($1.2M per $1M)	$1,901,000 ($1.4M per $1M)	$3,149,000 ($2.3M per $1M)
Twin Falls District sagebrush restoration	Idaho	Sagebrush restoration	2009–2014	$1,475,000	33.9 (23.0 per $1M)	$1,808,000 ($1.2M per $1M)	$2,008,000 ($1.4M per $1M)	$3,772,000 ($2.6M per $1M)

Table 4. Summary of national/Western States economic impacts for case study projects.—Continued

[M, million; NRDAR, Natural Resource Damage Assessment and Restoration; K, thousand; BLM, Bureau of Land Management]

Project	Location	Restoration type	Project period (start year–end year)	Total project expenditure (2014 dollars)	Job-years (Normalized per $1M of project expenditures)	Labor income (2014 dollars) (Normalized per $1M of project expenditures)	Value added (2014 dollars) (Normalized per $1M of project expenditures)	Economic output (2014 dollars) (Normalized per $1M of project expenditures)
Post-wildfire restoration—Miller Homestead post-fire restoration	Oregon	Post-fire restoration	2013-2014	$2,512,000	37.6 (15.0 per $1M)	$2,014,000 ($802K per $1M)	$2,968,000 ($1.2M per $1M)	$6,645,000 ($2.6M per $1M)
Post-wildfire restoration—Long Draw post-fire restoration	Oregon	Post-fire restoration	2013-2014	$5,525,000	89.5 (16.2 per $1M)	$5,263,000 ($953K per $1M)	$6,713,000 ($1.2M per $1M)	$13,514,000 ($2.4M per $1M)
Zuni Mountains forest restoration	New Mexico	Fuels reduction	2013–2014	$87,000	2.5 (28.7 per $1M)	$103,000 ($1.2M per $1M)	$121,000 ($1.4M per $1M)	$218,000 ($2.5M per $1M)

Transferring Economic Impact Estimates

Although economic impact estimates for restoration projects are often desired, it is not always possible for practitioners to collect the necessary data and develop the models needed to estimate the economic impacts of a restoration project. Therefore, it is common for practitioners to use "rules of thumb," such as generic impacts per $1 million estimates, to estimate the economic impacts of restoration projects. However, as the case studies demonstrate, there is a large amount of variation in the economic impacts of various restoration projects. The case studies, as well as a review of the literature, indicate that practitioners need to use caution when transferring economic impact estimates from one restoration project to another. This section provides some guidelines for consideration when transferring impact estimates from the case studies presented in this report or from any economic impact analysis.

There are three questions to be considered when transferring economic impact estimates: (1) Is the restoration work similar for the source and target projects? (2) Are the size and composition of the source and target economies similar? and (3) Does the source impact analysis use reasonable assumptions?

1. Economic impact analyses allocate project expenditures to different sectors of an economy based on the type of work that was done for the project. Projects that are composed of similar sets of restoration activities are likely to have similar economic impact estimates. As highlighted in the University of Oregon study, the mix of labor, equipment, and materials expenditures required for a project could be a good way for practitioners to assess the similarity of work types between projects (Nielsen-Pincus and Moseley, 2010). Projects that are composed of a similar breakdown of these categories are likely to affect different sectors of the economy in similar ways.
2. The scope and geography of the economy is another important consideration. Economic impacts of projects reported for larger economies (that is, the national, regional, or State-level impacts of a restoration project) are more valid for transfer to a different project than those made for smaller local economies. We suggest that economic impacts estimated for small local areas (that is, sub-State local areas) not be transferred because local economies surrounding project sites are variable and the effects on local economies are difficult to predict. Impact estimates are influenced by the composition of the local economy, which varies widely from place to place. Local impact estimates are also influenced by the percentage of project expenditures that are purchased within the local economy, which also varies widely from project to project. For example, among the 21 case study projects, the estimated percentage of project expenditures made in local project areas varied from <1 to 95 percent.
3. Modeling methods and assumptions can also play a large role in impact estimates. Some studies use unrealistic assumptions; for example, a study might assume that all expenditures were made in the local area or that all materials were purchased directly from the manufacture (that is, some studies may not account for retail markups in the costs of purchased materials). These assumptions can result in overestimates of economic impacts. Assumptions about the use of volunteer labor are another important factor to consider in transferring impact estimates. It is common for restoration projects to utilize some volunteer labor, which could reduce job impact estimates; however, the amount of volunteer labor utilized in a project is ordinarily not reported in economic impact analyses, so it can be difficult to account for that factor.

Lessons Learned

This project was designed as a pilot study to explore and assess the feasibility of collecting cost data and estimating the economic impacts of Federal restoration programs. The aim was to develop survey instruments and methods that would work across a wide range of restoration projects implemented by a wide range of individuals and institutions. Through this project, much was learned about the makeup of the restoration economy and about practitioners' ability and willingness to provide economic data. This section highlights some of the challenges that were faced and provides ideas and suggestions about how analysts might improve data collection and methods based on the lessons learned.

Our primary suggestion is to integrate cost data collection into routine management processes so that these data are collected as projects occur. For this study, cost data were collected after the projects were completed. In addition, participation in the study was voluntary. As a result, complete data were not provided because many firms and project managers did not have the data or were unwilling to provide the data. In many cases, project data were not retrievable because the contractor was no longer in business, the appropriate contact was no longer with the firm, or the files for the project had been archived. Many potential expenditure survey respondents were unwilling to complete the survey because they did not have the time or resources to complete the survey or they were unwilling to provide the financial data. For those who were willing to provide this information, many found the survey to be intractable because of the requested level of detail. In some cases, potential respondents had expenditure data that they were willing to share, but their data were organized in a manner that made it difficult to transfer to the expenditure categories in the expenditure survey. All of these challenges could be addressed through a collection process designed to collect cost data as project expenditures are made. It may also be necessary for the information collection to be mandatory in order to address the reluctance to participate.

Accurate information about the direct economic impacts of restoration projects is of paramount importance, and the need for this information provides further motivation for collecting economic data as projects are implemented. This study estimated direct economic impacts using data from the expenditure survey. Direct labor income and direct economic output were easily estimated using this data, but direct job-years were difficult to estimate. Direct job-years can be estimated either by asking for the number of labor hours required to complete the work or by dividing labor expenses by average hourly wage rates. This analysis relied on average hourly wage rate data provided in the expenditure survey; however, a large portion of respondents left the average hourly wage question blank, suggesting that this question was difficult to answer. In a previous iteration of the survey, respondents also had difficulty providing the number of labor hours required to complete the work (U.S. Department of the Interior, 2012). These difficulties suggest that collecting the data necessary to retrospectively estimate direct job-years for completed projects is genuinely challenging, and the best way to get this important information is to collect it while projects occur.

Several issues relating to the survey design and administration were identified that could be addressed before undertaking future project-level analyses or adapting the survey instruments for a larger scale data collection effort. Specifically:

- The two-step survey process that was used for this study involved (1) collecting information from the project manager using the project summary survey and (2) using information from the project summary survey to generate custom expenditure surveys for every project manager and contractor who worked on the project. This two-step process was labor intensive and, thus, would be difficult to adapt for a larger-scale study. To implement a larger-scale effort, we suggest that a system be developed that would require less back and forth communication among the economic analyst, the project manager, and project contractors.

- The format and delivery of the expenditure survey may have been a barrier to its completion for some contractors. In previous case studies, the expenditure survey was provided as a printable Word document to respondents and a phone date was scheduled with the respondent to complete the survey together over the phone (U.S. Department of the Interior, 2012). For the case studies completed as part of this analysis, the expenditure survey was provided as an Excel form. This format had the benefit of including data validation checks, but we have some reason to believe that the Excel form was intimidating to some respondents as it was delivered by email and respondents were asked to complete it on their own. The Word document and phone interview approach was more successful, and the use of a similar approach for future analyses is suggested.
- The expenditure survey asked respondents to break their expenditures down by percentages as opposed to dollar values. This method had the advantage of allowing respondents to estimate their expenditure breakdowns if they were unable to calculate the exact expenditure breakdowns for the project. Also, it was believed that asking for percentages instead of actual dollar values might make some respondents feel more comfortable with providing these financial data. The downside of asking for percentages instead of actual dollar values, however, is that it was difficult to determine if the provided percentages accurately reflected true expenditures. Furthermore, the percentage breakdown questions involved somewhat complicated mathematical thinking in terms of percentages of percentages, and several returned surveys indicated that some respondents did not understand what was being asked. In addition, respondents were not explicitly asked to identify the profits earned on the work, so a system had to be developed to remove profits and other nonlabor income components of value added from the estimated expenditure profiles. This process further abstracted expenditure estimates and added more room for error. Based on these experiences, it is suggested that future survey instruments ask for dollar values (not percentages) and explicitly ask respondents about profits and taxes.
- The restoration industry is diverse, and the surveys attempted to collect consistent information across this diverse population. In addition to firms keeping their financial data in different formats, several issues with terminology were encountered. For example, BLM project managers use the word “contract” to include both service and material purchases; a BLM project might have a contract for a restoration activity like seeding and a contract for material like seeds. In the survey, “contractor” was meant to include firms or individuals hired to complete a restoration activity, like seeding, and material purchases, like seeds, were expected to be included as nonlabor material expenditures. This is just one example of the many challenges in making a one-size-fits-all survey to gather economic data across the diverse restoration industry. Depending on the application, it may be worthwhile to customize future surveys toward target populations.

The “An Alternative Modeling Approach—The Best-Fit Sector Method” section provides details of an alternative approach for estimating the economic impacts of restoration projects, and the “Conclusions and Suggestions for Future Analyses” section provides some suggestions for future analyses and comments on tradeoffs to consider in selecting an analysis method.

An Alternative Modeling Approach—The Best-Fit Sector Method

Collecting the primary data needed to construct the project-level expenditure profiles using the analysis-by-parts method required a substantial amount of time and money and, as highlighted in the

“Lessons Learned” section, it was difficult to collect these data from some contractors. To evaluate whether the analysis-by-parts method was worth the effort, a simplified best-fit sector analysis method that requires fewer input data was developed, and each case study was evaluated using both the analysis-by-parts method and the best-fit sector method. This section describes the best-fit sector method and the results of the compared analysis.

The best-fit sector analysis primarily used the information obtained in the project summary survey; the detailed expenditure data collected in the expenditure survey were not used. Using information from the project summary survey, total project expenditures were broken down into expenditures by restoration action and each restoration action was then matched to a best-fit IMPLAN sector. Appendix 4 provides the crosswalk that was developed to match restoration actions to best-fit IMPLAN sectors. Expenditures by restoration action were applied to their respective best-fit sectors. For each restoration action, the event year was set to the year that the restoration action began. For the national/Western States models, all project expenditures were applied to the model, and local purchase percentages were set to 100 percent; this assumes that 100 percent of the direct expenditures for each restoration action were purchased within the national or Western States economy. For local models, only expenditures that were made by firms located within the local area were applied to the model; all expenditures for restoration activities that were completed by firms located outside of the local area were excluded from the model and it was assumed that they did not generate any local economic activity. As with the national/Western States models, the local purchase percentages for local models were set to 100 percent. Management activities for government projects were modeled using the “Federal Government Non-Defense” and the “State/Local Government Non-Education” institutional spending patterns. Local purchase percentages for these government activities were set to SAM model values.

The differences in impact estimates between the analysis-by-parts and the best-fit sector methods vary across case studies. For several of the case studies, the two methods produced relatively similar results, but the results differ substantially for other case studies. Compared to the best-fit sector method, the analysis-by-parts method for the national/Western States models produces larger impacts for some case studies and smaller impacts for others. Estimated national or Western States level impacts were smaller for the best-fit sector method as compared to the detailed analysis-by-parts method for 13 of the 19 comparable models. For local models, the analysis-by-parts estimates were typically larger than the best-fit sector estimates. Estimated local level impacts were smaller for the best-fit sector method as compared to the detailed analysis-by-parts method for 12 of the 17 comparable models. This is primarily attributable to the fact that the analysis-by-parts method includes local expenditures made by nonlocal firms, whereas the best-fit sector method leaks all expenditures made by nonlocal firms from the local economy. It is difficult to know what the true economic impacts of a project are, but we assume that the detailed analysis-by-parts method produces better estimates of the true impacts than the alternative best-fit sector method because it utilizes better information about how dollars are spent within economies. These results indicate that the best-fit sector method may underestimate the economic impacts of ecosystem restoration projects, but this is just an observation based on a small number of case studies.

Because there are a relatively limited number of case studies to compare, a quantitative answer to the question of whether collecting all of the data for the analysis-by-parts method was worth the effort cannot be provided. We believe that the detailed approach produces better impact estimates, but the tradeoff between accuracy and effort cannot be quantified. That said, based on experience, it seems that the data collection process for the analysis-by-parts method could be simplified, adjusted, and potentially combined with a best-fit sector approach to develop a system that could accurately and consistently collect data at a larger scale.

Conclusions and Suggestions for Future Analyses

The case studies highlighted in this report provide a window into the complex and collaborative restoration economy and demonstrate the meaningful economic impacts associated with investments in ecosystem restoration. In addition to providing improved information on the economic impacts of restoration, these case studies highlight DOI and BLM restoration efforts and tell personalized stories about each project and the communities that are positively affected by restoration activities. The case studies demonstrate a large amount of variation in the economic impacts supported by restoration investments and indicate that restoration type, costs, availability of inputs and labor, and modeling methods all play large roles in impact estimates. The substantial variation in economic impacts between case study projects demonstrates that practitioners need to use caution when transferring economic impact estimates from one restoration project to another. That said, the DOI case studies published in this report and available online at https://www.fort.usgs.gov/economic-impacts-restoration provide a source of economic impact estimates that could be transferred to approximate the economic impacts of similar restoration projects.

A primary objective of this study was to develop and test methods that could inform future analyses and to assess the feasibility of collecting cost data to estimate the economic impacts of Federal restoration programs at a national scale. One of the most important steps toward estimating the economic impacts of restoration programs is to develop a reporting system that would collect information on the timing, amount, and location of project expenditures. Ideally, project managers and contractors would be required to provide the information, and the information would be collected as expenditures are made during the life of a project.

Based on the experiences and lessons learned, the following options are suggested for future data collection and impact analyses.

1. *Use an analysis-by-parts approach, and collect data as expenditures occur.*—The survey instruments developed for this analysis could be modified to develop an ongoing monitoring program that would capture the direct economic impacts of restoration projects and develop expenditure profiles that could be used to estimate secondary impacts using the analysis-by-parts method. As mentioned in the “Lessons Learned” section, we suggest that the collection of the cost data be integrated into routine management processes and collected as projects occur.
2. *Use a best-fit sector approach.*—Methods for a best-fit sector approach are provided in the “An Alternative Modeling Approach—The Best-Fit Sector Method” section of this report, and a table that bridges common restoration activities to the best-fit IMPLAN sectors is provided in appendix 4. Using contractor NAICS codes to determine the appropriate best-fit sector could be a good, low-cost option for estimating the economic impacts of projects. The upside of this approach is that it is relatively simple to implement and requires relatively minimal data. The downside to this approach is that some restoration activities are not well matched to IMPLAN sectors. Referring to the table of best-fit IMPLAN sectors in appendix 4, the best-fit sectors for project management activities, terrestrial and stream construction activities, some landscape treatment activities, and other restoration construction activities are not good fits. For example, to model project management activities that are implemented by government agencies, the study used the “Federal Government Non-Defense” or the “State/Local Government Non-Education” institutional spending patterns provided in the IMPLAN software. These government spending patterns are generally representative of all government non-defense and non-education expenditures and, thus, are not necessarily good representations of specific government restoration planning activities. As another example, terrestrial and stream construction activities

were matched to the "Support activities for other mining" IMPLAN sector based on a similarly high reliance on engineers and earth-moving machinery; however, mining support activities and terrestrial and stream construction activities are very different activities. Similarly, some landscape treatment activities and other restoration construction activities were matched to sectors that are not good fits.

3. *Use a combined best-fit sector and analysis-by-parts approach.*—Project management activities, as well as restoration activities implemented in-house by government agencies, are not well matched to IMPLAN sectors. Projects managed by government agencies and nongovernmental organizations could track expenditure data and direct economic impacts as projects occur and use NAICS codes to match private expenditures to best-fit IMPLAN sectors. The Forest Service and the Fish and Wildlife Service already have monitoring systems in place to track Federal project expenditures, and these systems could serve as examples.
4. *Utilize generalizable production functions for restoration activities.*—The Forest Service and the University of Oregon Ecosystem Workforce Program developed a national survey to elicit expenditure patterns from a variety of restoration contractors and are developing a library of restoration production functions relevant to forest and watershed restoration projects. The Forest Service and EWP have begun to use these newly developed restoration expenditure profiles to estimate and predict the economic impacts of several forest restoration projects in Oregon (Loughery and White, 2014; Bennett and others, 2015; White and Bennett, 2015). These expenditure profiles could be useful for estimating the economic impacts of proposed BLM restoration projects as part of BLM planning processes. More broadly, these expenditure profiles could be combined with a direct economic impact tracking system to develop an improved analysis-by-parts method. The expenditure profiles developed by the Forest Service and EWP are specific to forest and watershed restoration projects, so an expanded survey effort would be required to develop expenditure profiles for a wider range of restoration types.
5. *Transfer impact estimates from a similar restoration project.*—It is not always possible for practitioners to collect the necessary data and develop the models needed to estimate the economic impacts of a restoration project. This may be due to time and budget constraints or because impact estimates are needed as part of the planning process for a project that has not yet occurred. In these cases, impacts can be approximated by transferring impact estimates from a similar project for which impacts have already been estimated. The "Transferring Economic Impact Estimates" section in this report provides guidance on matters to consider and precautions when transferring estimates from one restoration project to another.

Selecting a data collection and modeling approach will depend on the objectives of the analysis, the available budget, and the willingness or ability of a program to make a long-term institutional investment. For planning purposes and one-off analyses, options 1, 2, or 5 could be implemented depending on data availability. For long-term monitoring and for program assessment, options 3 or 4 provide good alternatives for programs to consider.

References Cited

Baker, J.M., 2005, Socio-economic characteristics and contributions of the natural resources restoration system in Humboldt County, California: Ecological Restoration, v. 23, no. 1, p. 5–14.

BenDor, Todd; Lester, T.W.; Livengood, Avery; Davis, Adam; and Yonavjak, Logan, 2015, Estimating the size and impact of the ecological restoration economy: PLoS ONE, v. 10, no. 6, accessed August 25, 2015, at http://dx.doi.org/10.1371/journal.pone.0128339.

Bennett, Drew; Davis, E.J.; White, E.M.; and Ellison, Autumn, 2015, Economic impacts from the Malheur 10-year Stewardship Contract—Evaluating year one: University of Oregon, Ecosystem Workforce Program, Fact Sheet 5, 2 p., accessed August 25, 2015, at http://ewp.uoregon.edu/sites/ewp.uoregon.edu/files/FS_5.pdf.

Dillman, D.A, 2011, Mail and Internet surveys—The tailored design method (2d ed.): New York, Wiley, 544 p.

Goad, Jessica; Goldfuss, Christy; and Kenworthy, Tom, 2011, The jobs case for conservation—Creating opportunity through stewardship of America's public lands: Center for American Progress, accessed August 25, 2015, at https://www.americanprogress.org/issues/green/report/2011/09/20/10343/the-jobs-case-for-conservation/.

Headwaters Economics, 2014, The economic impacts of restoration—Custer and Lemhi Counties, Idaho: Headwaters Economics, 16 p., accessed August 25, 2015, at http://headwaterseconomics.org/wphw/wp-content/uploads/Idaho_Restoration_Report.pdf.

Hjerpe, E.E., and Kim, Yeon-Su, 2008, Economic impacts of southwestern national forest fuels reductions: Journal of Forestry, v. 106, no. 6, p. 311–316.

Hurd, Josh, 2009, Economic benefits of watershed restoration: Missoula, Mont., Wildlands CPR, Political Economy of Watershed Restoration Series, 21 p., accessed August 25, 2015, at http://www.hydroreform.org/sites/default/files/Hurd_Economic_Benefits_2009_0.pdf.

IMPLAN Group, LLC, 2012, IMPLAN v3.0 2012 national data set: IMPLAN Group, LLC, accessed January 1, 2013, at http://www.implan.com/.

Industrial Economics, 2012, Economic impacts of ecological restoration in Massachusetts: Massachusetts Department of Fish and Game, 30 p., accessed August 25, 2015, at http://www.mass.gov/eea/docs/dfg/der/pdf/economic-impacts-ma-der.pdf.

Kim, Yeon-Su, 2010, Ecological restoration as economic stimulus—A regional analysis: Flagstaff, Ariz., Northern Arizona University Ecological Restoration Institute, 20 p., accessed August 25, 2015, at http://library.eri.nau.edu/gsdl/collect/erilibra/index/assoc/HASH01a0/f2bebf05.dir/doc.pdf.

Laughland, Drew; Phu, Linh; and Milmoe, Joe, 2013 [2014], Restoration returns—The contribution of Partners for Fish and Wildlife Program and Coastal Program restoration projects to local U.S. economies: U.S. Fish & Wildlife Service, 42 p., accessed August 25, 2015, at http://www.fws.gov/home/pdfs/restoration-returns.pdf.

Loughery, Kristen, and White, Eric, 2014, Socioeconomics report—Lower Joseph Creek restoration project, Wallowa-Whitman National Forest, Wallowa County, Oregon: U.S. Forest Service, 50 p., accessed August 25, 2015, at http://a123.g.akamai.net/7/123/11558/abc123/forestservic.download.akamai.com/11558/www/nepa/97651_FSPLT3_2417559.pdf.

Nielsen-Pincus, Max, and Moseley, Cassandra, 2010, Economic and employment impacts of forest and watershed restoration in Oregon: University of Oregon, Institute for a Sustainable Environment, Ecosystem Workforce Program, Working Paper Number 24, 28 p., accessed January 1, 2012, at http://www.oregoncoastalliance.org/documents_13/Restoration_Economy_Study_2010.pdf.

Pendleton, Linwood, 2010, Measuring and monitoring the economic effects of habitat restoration—A summary of a NOAA Blue Ribbon Panel: Duke University, Nicholas Institute for Environmental Policy Solutions, 60 p., accessed August 25, 2015, at http://www.era.noaa.gov/pdfs/NOAA%20RAE%20BRP%20Estuary%20Economics_FINAL.pdf.

Southwick Associates, 2013, The conservation economy in America—Direct investments and economic contributions: Washington, D.C., The National Fish and Wildlife Foundation, accessed August 25, 2015, at https://rfflibrary.wordpress.com/2013/05/10/the-conservation-economy-in-america-direct-investments-and-economic-contributions/.

Southwick Associates and Responsive Management, 2013, Economic impact analysis of the collaborative forest landscape restoration program: Responsive Management, 20 p., accessed August 25, 2015, at http://www.fs.fed.us/restoration/documents/cflrp/results/AcceleratingLongleaf/EconomicAnalysisCFLRPreport.pdf.

The Nature Conservancy, 2010, Investing in nature—Creating jobs and restoring coastal habitats: National Oceanic and Atmospheric Administration, 42 p., accessed August 25, 2015, at http://www.habitat.noaa.gov/pdf/tnc_noaa_arra_restoration_summary.pdf.

U.S. Department of Agriculture, 2015, Collaborative forest landscape restoration program—5-year report, FY 2010–2014: U.S. Forest Service FS-1047, 16 p., accessed August 25, 2015, at http://www.fs.fed.us/restoration/documents/cflrp/CFLRP_5-YearReport.pdf.

U.S. Department of the Interior, 2012, The Department of the Interior's economic contributions, Fiscal Year 2011: U.S. Department of the Interior, 225 p., accessed August 25, 2015, at https://www.doi.gov/sites/doi.gov/files/uploads/2011-Econ-Report-FINAL-07_27_2012.pdf

Wagner, Barbara, and Shropshire, Robin, 2009, An estimation of Montana's restoration economy: Montana Department of Labor and Industry, 28 p., accessed August 25, 2015, at http://www.ourfactsyourfuture.org/media/9321/restoration.pdf.

White, E.M., and Bennett, Drew, 2015, Application of the forest restoration and utilization calculator—Economic effects from potential forest management in Jackson County, OR: University of Oregon, Institute for a Sustainable Environment, Ecosystem Workforce Program Fact Sheet 10, 2 p., accessed August 25, 2015, at http://ewp.uoregon.edu/sites/ewp1.uoregon.edu/files/images/resources/economy/FS_10.pdf.

Appendix 1. Case Studies—The Economic Effects of 21 Ecosystem Restoration Projects

Appendix 1 provides the 21 Natural Resource Damage Assessment and Restoration and Bureau of Land Management case studies used to study the economic effects of ecosystem restoration projects. The case studies are also available from an online database at https://www.fort.usgs.gov/economic-impacts-restoration. The online database of case studies can be sorted and filtered by primary restoration type, and the database contains additional U.S. Department of the Interior (DOI) restoration case studies that were first published in the DOI economic contributions report for fiscal year 2011 (U.S. Department of the Interior, 2012).

Economic Impacts of the Lone Mountain NRDAR Settlement in the Powell River Watershed

In October 1996, a coal slurry impoundment associated with a coal processing plant owned by Lone Mountain Processing, Inc., in Lee County, Virginia, failed and released six million gallons of coal slurry into the Powell River watershed. “Blackwater,” a mixture of water, coal fines, clay, and associated contaminants, extended more than 20 miles downstream from the spill site. The Powell River watershed is part of the Upper Tennessee River Basin, which comprises one of the nation’s most biologically diverse aquatic ecosystems (U.S. Fish and Wildlife Service, 2003). The coal slurry spill affected fish and endangered freshwater mussels, other stream organisms, and supporting aquatic habitat, including designated critical habitat for two Federally listed fish—the yellowfin madtom (*Noturus flavipinnis*) and the slender chub (*Erimystax cahni*). A Natural Resource Damage Assessment and Restoration (NRDAR) settlement required that Lone Mountain Processing, Inc., pay $2,450,000 in damages for the natural resource injuries caused by the slurry spill to restore fish, mussels, and the habitats that support them. As part of this settlement, more than 500 acres of riparian land in southwestern Virginia have been preserved in partnership with The Nature Conservancy to protect habitat for aquatic organisms and other species, such as bats and songbirds.

This case study tells the story of five restoration projects in the Upper Tennessee River Basin that were supported by the Lone Mountain NRDAR settlement and the economic activity generated through expenditures on these projects. The highlighted restoration projects include: two mussel and fish propagation and reintroduction projects that are working to replace freshwater mussels and fish species killed during the spill, two instream and riparian restoration projects designed to provide fish and mussel habitat and to provide recreation and education opportunities in Lee County, and one acid mine drainage abatement project designed to improve water quality in the watershed. Figure 1-1 shows a map of the spill site and the five highlighted restoration projects. The U.S. Geological Survey collected data on restoration activities and expenditures to estimate the economic activity supported by these restoration projects.

Background information on the Lone Mountain NRDAR settlement was obtained from Anne Condon, U.S. Fish and Wildlife Service Virginia Field Office, written commun., 2015; and from Lone Mountain NRDAR case documents at http://www.cerc.usgs.gov/orda_docs/CaseDetails?ID=914.

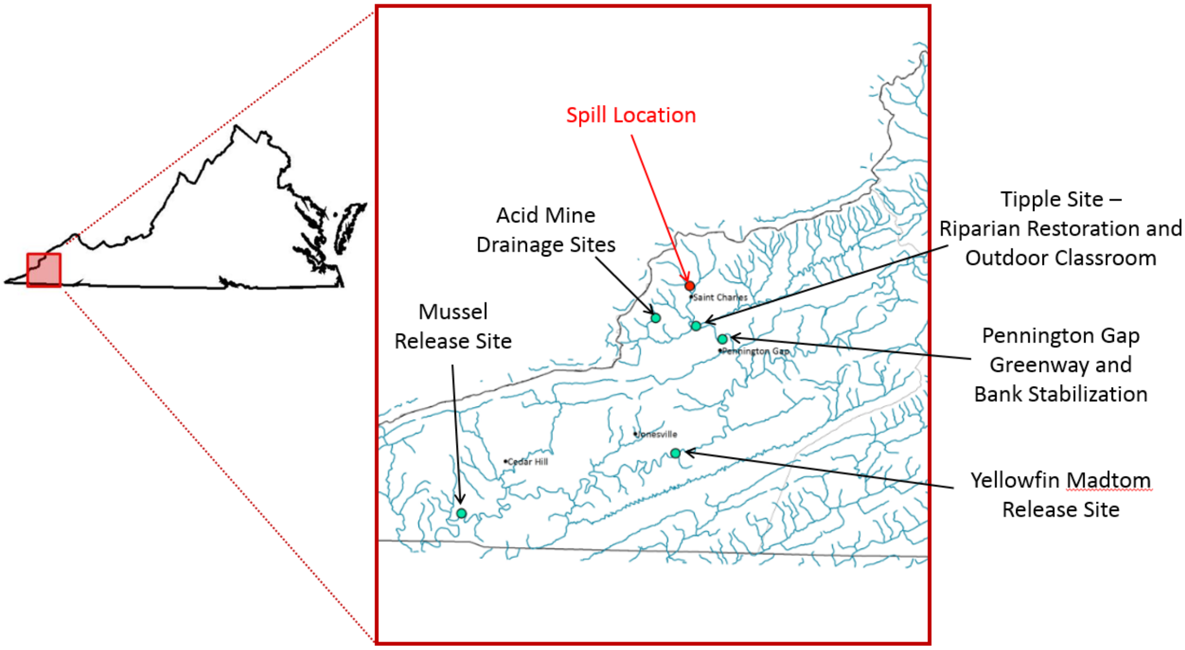


Figure 1-1. Five restoration projects in the Powell River watershed in Virginia supported by the Lone Mountain Natural Resource Damage Assessment and Restoration settlement.

Freshwater Mussel Restoration

Background information.—Historically, the Powell River supported abundant and diverse populations of freshwater mussels. In recent decades, mussel density and species richness have declined and many freshwater mussel species are listed as either State or Federally threatened or endangered species. Environmental degradation from coal mining has been identified as one of the drivers of this decline. An example is the 1996 Lone Mountain slurry spill that directly affected mussel populations, as well as their host fish species.

Freshwater mussels feed by filtering small particles from water, thereby improving water quality and providing an essential ecosystem service in rivers and streams. Mussels also serve as a food source for fish, reptiles, birds, and mammals, and mussel shells provide nesting sites for small fish. Mussel filtering helps clean water, but this filtering makes mussels vulnerable to environmental contamination. Mussels typically have average lifespans of 20 to 100 years depending on the species; because of this long lifespan, mussel populations injured by contaminants may take many years to recover (Freshwater Mollusk Conservation Center, 2015).

Tagged mussels ready to be released into the river. Photo credit: Freshwater Mollusk Conservation Center.

Utilizing funds from the Lone Mountain Natural Resource Damage Assessment and Restoration (NRDAR) settlement, scientists with the Virginia Tech Freshwater Mollusk Conservation Center, Virginia Department of Game and Inland Fisheries, and U.S. Fish and Wildlife Service worked collaboratively to propagate, restore, and monitor endangered mussels in the Powell River watershed.

Release of propagated mussels at Bales Ford, Tennessee. Photo Credit: Freshwater Mollusk Conservation Center.

The recovery team used both hatchery-reared mussels and translocated adult mussels to augment populations of endangered mussel species in the river. Freshwater mussels require the use of a host fish to complete their life cycle. To propagate mussels in captivity, scientists collect suitable host fish and pregnant female mussels from the river. In the laboratory, larvae from female mussels are introduced to host fish and attach to the gills of the fish where they grow and transform into juveniles. Once the juveniles drop from their host fish, they are collected and fed cultured algae and pond water until they achieve the desired size for release to the wild, usually at 20 millimeters long and 1–2 years of age. The mussel hatcheries operated by the Virginia Tech Freshwater Mollusk Conservation Center and the Virginia Department of Game and Inland Fisheries annually produce and release 10,000 to 20,000 or more juvenile mussels of 6–10 different species. By releasing propagated mussels biannually from 2004 to 2012, the program has restored populations of several endangered species. Ongoing monitoring efforts, funded through other sources, will determine the success of these releases.

Background information on freshwater mussel restoration for the Lone Mountain NRDAR settlement was obtained from Jess Jones, U.S. Fish and Wildlife Service Gloucester Field Office, written commun., 2015; the Virginia Tech Freshwater Mollusk Conservation Center Website at http://www.fishwild.vt.edu/mussel/; and from Lone Mountain NRDAR case documents at http://www.cerc.usgs.gov/orda_docs/CaseDetails?ID=914.

Economic impacts.—The Powell River mussel propagation program began in 2004 and ran through 2012. The Lone Mountain NRDAR settlement supported $697,000 (2014 dollars) in program costs, but additional funding from other NRDAR settlements, State programs, and in-kind contributions were necessary to successfully execute the program and enable the restoration to continue for an extended period of time. This analysis is focused on the mussel propagation funding obtained from the Lone Mountain NRDAR settlement and does not include economic impacts of additional funds.

Lone Mountain NRDAR funds directly supported research scientists, university students, State biologists and the mussel propagation facilities and program. Most of these expenditures were spent within the State of Virginia but outside of the local area surrounding the project site, so the project had only a small local economic impact. Expanding to include both local and nonlocal project expenditures, the Lone Mountain NRDAR Powell River mussel propagation program supported an estimated total of 21.2 job-years; $962,000 in labor income; $1,191,000 in value added; and $1,948,000 in economic output in the national economy. The program has also advanced scientific knowledge and understanding of freshwater mussels, improving the likelihood of successful mussel conservation in the future.

Freshwater Mussel Restoration

Total project expenditures: $697,000

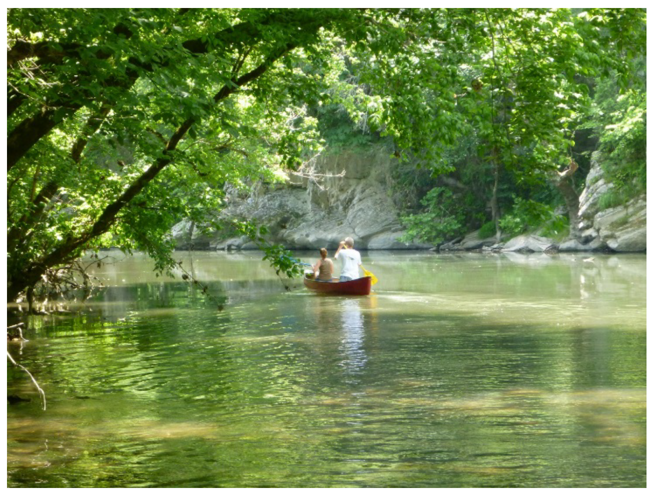
National economic impacts:
- 21.2 job-years
- $962,000 in labor income
- $1,191,000 in value added
- $1,948,000 in economic output

Local project expenditures: $30,000

Local economic impacts:
- 0.0 job-years
- $0 in labor income
- $0 in value added
- $30,000 in economic output

Endangered Fish Restoration

Young, propagated yellowfin madtoms acclimating in a bag in the river before release in June 2008. Photo credit: Conservation Fisheries, Inc.



Conservation scientists paddle to a release site, transporting bags of propagated fish. Photo credit: Conservation Fisheries, Inc.

Background information.—The Lone Mountain slurry spill injured two endangered fish species in the Powell River—the yellowfin madtom (*Noturus flavipinnis*) and the slender chub (*Erimystax cahni*). The yellowfin madtom was historically widespread throughout the Upper Tennessee River drainage but was presumed extinct at the time of its formal scientific description. The discovery of three surviving but geographically isolated populations in the late 1970s and early 1980s resulted in its listing as a threatened species. The slender chub was also once relatively common in the Powell River but is now listed as one of the most narrowly distributed minnows in North America. Both the yellowfin madtom and the slender chub are sensitive to chemical pollution and sedimentation, and sediment and contaminants from the Lone Mountain spill contributed to the degradation of habitat for these endangered fish species (U.S. Fish and Wildlife Service, 2003).

Conservation Fisheries, Inc., (CFI), a Tennessee nonprofit organization that specializes in the conservation and captive propagation of rare freshwater fish, has been propagating yellowfin madtoms to try to reestablish populations lost in the spill. The organization collects wild madtom nests from the stream, rears the fish in their hatchery, and then releases the reared fish back into the wild. Experience from other yellowfin madtom restoration efforts suggests that it may take more than 15 years to restore populations (Patrick Rakes, CFI, written commun., 2015). Madtoms invest their energy in producing relatively few young, of which they take better care than other fish species, resulting in only a few hundred juveniles produced for release each year (Patrick Rakes, CFI, written commun., 2015). It is difficult to make any definitive statements about the success of the Powell River yellowfin madtom restoration because of the biology of the species and the nature of the river. Yellowfin madtoms are cryptic, so they are difficult to find even when they are doing well and they are especially difficult to find when they are just getting reestablished. Despite this challenge, CFI remains hopeful and is encouraged that the Powell River yellowfin madtom population can rebound. To mark this optimism, the group has observed survivorship of released fish up to two years after release, nesting pairs and two nests of eggs, and at least one untagged juvenile that was spawned in the wild at one of the release sites.

Conservation Fisheries, Inc., is less optimistic about the fate of the Powell River slender chub. The slender chub is one of the rarest fish in eastern North America, and only a few specimens have been collected in the past 20 years. The species was considered rare to moderately common in the Powell River and the nearby Clinch River as recently as the early 1980s, but its precipitous decline since then is cause for concern that the species is in danger of extinction. Despite continued search efforts, CFI has been unable to obtain specimens for captive propagation of this highly imperiled fish.

Background information on endangered fish restoration for the Lone Mountain Natural Resource Damage Assessment and Restoration (NRDAR) settlement was obtained from Patrick Rakes, CFI, written commun., 2015; and from Lone Mountain NRDAR case documents at http://www.cerc.usgs.gov/orda_docs/CaseDetails?ID=914.

Economic impacts.—Work to restore the yellowfin madtom began in 2004 and continued through 2014. As of 2014, $177,000 (2014 dollars) in Lone Mountain NRDAR funds have gone to support the propagation and reintroduction of the yellowfin madtom in the Powell River, providing an average of $16,000 per year for fisheries conservation in the watershed. A small percentage of project expenditures was spent in the local area surrounding the project site, so the project had only a small effect on the local economy. Expanding to include all project expenditures, NRDAR funding for yellowfin madtom propagation has supported a total of 5.6 job-years; $259,000 in labor income; $313,000 in value added; and $529,000 in economic output in the national economy.

Endangered Fish Restoration

Total project expenditures: $177,000

National economic impacts:
- 5.6 job-years
- $259,000 in labor income
- $313,000 in value added
- $529,000 in economic output

Local project expenditures: $1,000

Local economic impacts:
- 0.0 job-years
- $0 in labor income
- $0 in value added
- $1,000 in economic output

Tipple Site—Riparian Restoration and Outdoor Classroom

Background information.— The Powell and Clinch Rivers provide vital habitat for many forms of wildlife and are inhabited by one of the world's richest and most diverse assemblages of freshwater mussels (U.S. Fish and Wildlife Service, 2003). The rivers are also multiple-use recreation areas and a valuable water source that supplies water for the residents of Lee County, Virginia. The Lone Mountain coal slurry spill released sediment and hazardous substances affecting water quality and impacting 12 Federally listed mussels and critical habitat for 2 Federally listed fish.

A natural resources class from the Lee County Career and Technical Center planted trees in the riparian area. Photo credit: Upper Tennessee River Roundtable.

Fish and mussel habitat depends on the riparian habitats surrounding the river. In order to recover lost fish and mussel habitat, the Lone Mountain Natural Resource Damage Assessment restoration plan calls for protection and enhancement of riparian habitat by stabilizing stream banks and planting riparian buffers. By restoring the natural riparian structure and function, these restoration activities can enhance natural mussel and fish recovery and improve water quality. The restoration plan also calls for educational outreach to enhance community knowledge of natural resources and to promote their protection and conservation.

Community members make stepping stones at day camp. Photo credit: Upper Tennessee River Roundtable.

One example of a restoration project that achieved these objectives took place in the Stone Creek community of Lee County, where many partners came together to reclaim and restore a stretch of stream habitat and transform the site of a former coal tipple yard into an outdoor classroom and park. The project at the Tipple site was implemented by the U.S. Fish and Wildlife Service in coordination with the Upper Tennessee River Roundtable and many community and funding partners.

To remediate the Tipple site, the Virginia Department of Mines, Minerals and Energy removed coal facilities and loading structures and capped the site with a 2-foot layer of soil. To restore the stream, fill material was added to the streambank and rootwads were installed to provide fish habitat. Trash, debris, and invasive species were removed from the site, and streambanks were stabilized using matting and native vegetation. A 25-foot-wide riparian corridor was established with native vegetation along the length of the property, and a wetland was constructed where the site naturally drains. An AmeriCorps National Civilian Community Corps team helped remove invasive plants and install riparian plantings; local organizations, businesses, and community members worked together to plant trees and construct an outdoor classroom and a trail in the park. The outdoor classroom features eight learning stations to help students learn about wetlands and the history of coal mining in the area.

Background information on the Tipple site restoration for the Lone Mountain Natural Resource Damage Assessment and Restoration (NRDAR) settlement was obtained from Carol Doss, Upper Tennessee River Roundtable, written commun., 2015; and from Lone Mountain NRDAR case documents at http://www.cerc.usgs.gov/orda_docs/CaseDetails?ID=914.

Before and after photos of the Tipple site. Photo credit: Upper Tennessee River Roundtable.

Economic impacts.—The Tipple site remediation and restoration project began in 2011 and was completed in 2014 with a total project cost of $214,000 (2014 dollars). Of these expenditures, $45,000 went towards purchasing the site; this amount is not included in the economic impact analysis. Of the remaining expenditures of $169,000, more than 65 percent was spent within the local area surrounding Lee County, and five local companies were contracted to work on the project. Including direct and secondary effects, the project supported an estimated 1.7 job-years; $62,000 in labor income; $88,000 in value added; and $169,000 in economic output in the local economy surrounding Lee County. Expanding to include both local and nonlocal expenditures, the project supported an estimated total of 3.0 job-years; $164,000 in labor income; $244,000 in value added; and $421,000 in economic output in the national economy.

Riparian Restoration and Outdoor Classroom

Total project expenditures: $169,000

National economic impacts:
- 3.0 job-years
- $164,000 in labor income
- $244,000 in value added
- $421,000 in economic output

Local project expenditures: $109,000

Local economic impacts:
- 1.7 job-years
- $62,000 in labor income
- $88,000 in value added
- $169,000 in economic output

Pennington Gap—Riparian Restoration and Community Park Development

Background information.—To restore fish and mussel habitat lost in the Lone Mountain coal slurry spill, the Natural Resource Damage Assessment and Restoration (NRDAR) plan calls for riparian habitat restoration to improve existing stream conditions, particularly by stabilizing streambanks in problem areas and planting appropriate riparian buffers throughout the watershed.

The Powell River runs through Leeman Field Park in Pennington Gap, Virginia, the largest population center near the Lone Mountain spill site. Through this reach, the river experienced streambank erosion and loss of instream habitat because of channel instability, changes in stormwater runoff, and loss of riparian vegetation along the streambank.

Pennington Gap Middle School students plant trees.
Photo credit: Upper Tennessee River Roundtable.

Using Lone Mountain NRDAR settlement funds, the U.S. Fish and Wildlife Service, the Upper Tennessee River Roundtable, the Virginia Department of Game and Inland Fisheries, and several other community and business partners worked together to restore more than 700 feet of the Powell River running through Leeman Field. Streambanks were stabilized by using natural bioengineering techniques, and riffle and pool sequences were created to provide diverse streambed fish and mussel habitat. Upland areas were treated to remove invasive plants, and more than 1,000 native trees and other native vegetation were planted. In the restored reach, streamflow is now increased during normal flows and adequate flood storage is maintained during storm events.

In addition to improving stream health, the Leeman Field river restoration project added recreational opportunities for residents and visitors to Lee County. The City of Pennington Gap is constructing a 1.5-mile greenway trail parallel to the stream. The stream restoration and trail will provide outdoor recreation opportunities, such as hiking, biking, and fishing, as well as community outreach and education about the importance of riparian health for water quality and instream habitat.

A National Civilian Conservation Corps team assists with riparian planting in April 2012. Photo credit: Upper Tennessee River Roundtable.

Background information on the Pennington Gap restoration for the Lone Mountain NRDAR settlement was obtained from Carol Doss, Upper Tennessee River Roundtable, written commun., 2015; and from Lone Mountain NRDAR case documents at http://www.cerc.usgs.gov/orda_docs/CaseDetails?ID=914.

Economic impacts.—Planning for the Pennington Gap riparian restoration project began in 2011 and restoration was completed in 2014 at a cost of $93,000 (2014 dollars). Many of the materials needed for the restoration, such as rocks, trees, straw, and gasoline, were purchased locally, and more than 50 percent of direct project expenditures were spent within the local economy. During the course of the project, the Pennington Gap riparian restoration project is estimated to have supported 0.9 total job-years; $27,000 in labor income; $34,000 in value added; and $86,000 in economic output in the local economy. Expanding to include both local and nonlocal expenditures, this project supported an estimated 1.6 total job-years; $95,000 in labor income; $138,000 in value added; and $239,000 in economic output in the national economy. Restoration of the stream has long-term benefits beyond these immediate economic impacts, including valuable ecological services such as improved wildlife habitat, floodwater control, erosion control, intrinsic values, aesthetic values, and ecotourism values.

Riparian Restoration and Community Park Development

Total project expenditures: $93,000

National economic impacts:
- 1.6 job-years
- $95,000 in labor income
- $138,000 in value added
- $239,000 in economic output

Local project expenditures: $47,000

Local economic impacts:
- 0.9 job-years
- $27,000 in labor income
- $34,000 in value added
- $86,000 in economic output

Acid Mine Drainage Abatement

Background information.—The Powell River watershed has a long history of coal mining. Prior to August 3, 1977, Virginia laws and regulations required the reclamation of areas affected by coal surface mining, but there were no regulations addressing reclamation of underground mines. Flows or seeps from these abandoned mines have long degraded the waters of the Powell River watershed (U.S. Department of Agriculture, 2008). Water that is discharged from these sites can be highly acidic and it commonly contains high concentrations of dissolved iron and aluminum sulfates. This acid mine drainage degrades the water quality of streams and water supplies and is a major contributor to aquatic habitat degradation.

Led by the Virginia Department of Mines, Minerals and Energy (DMME), there has been a growing partnership between State, Federal, and local agencies to abate acid mine drainage in the watershed. Using funds from the Lone Mountain Natural Resource Damage Assessment settlement, the DMME, Lee County, the Daniel Boone Soil and Water Conservation District, and the Upper Tennessee River Roundtable partnered to implement three acid mine drainage abatement projects to support improved water quality and aquatic habitat in the region injured by the Lone Mountain coal slurry spill. The acid mine drainage abatement projects are located along Ely Creek on lands owned by Lee County.

Acid mine drainage is produced when the oxygen in water reacts with iron sulfide materials that are found in most coal deposits. Resulting pollutants include iron sulfates, sulfuric acid, iron hydroxides, and ferric, aluminum and manganese salts. When dissolved in water at critical concentrations, these pollutants become toxic to fish, invertebrates, and aquatic plant life (U.S. Department of Agriculture, 2008). To neutralize acid mine drainage at the three project sites, passive limestone treatment systems were built to raise the pH of the acid mine drainage. Treatment systems at each site were uniquely designed for the sites and were constructed by a local excavating company. The treatment systems include either open limestone channels or closed limestone drains combined with polishing ponds. The pH of the acid mine drainage is neutralized as it passes through the limestone channels

Acid mine drainage in Ely Creek before restoration. Photo credit: Virginia Department of Mines, Minerals and Energy.

Open limestone channel. Photo credit: Virginia Department of Mines, Minerals and Energy.

Polishing pond used to neutralize acid mine drainage. Photo credit: Virginia Department of Mines, Minerals and Energy.

or drains, then the water is further neutralized and heavy metals are precipitated in the polishing ponds. The improved water is then discharged into Ely Creek.

The acid mine drainage abatement projects implemented on Ely Creek are a substantiated success. Downstream of the three projects, the water from Ely Creek merges with Stone Creek. In 2002, the 3-mile stretch of Stone Creek directly below this confluence was listed as impaired because it failed to support the general standard for aquatic life. The upstream Ely Creek acid mine drainage abatement projects were implemented in 2011. By 2014, biological sampling indicated that the downstream Stone Creek segment was fully supporting aquatic life, and the U.S. Environmental Protection Agency and the Virginia Department of Environmental Quality officially delisted Stone Creek from Virginia's Section 303(d) list of impaired waters under the Clean Water Act (O'Quinn, 2014).

Background information on acid mine drainage abatement for the Lone Mountain Natural Resource Damage Assessment and Restoration (NRDAR) settlement was obtained from Richard Davis, Virginia Department of Mines, Minerals and Energy, written commun., 2015; and from Lone Mountain NRDAR case documents at http://www.cerc.usgs.gov/orda_docs/CaseDetails?ID=914.

Economic impacts.—The three Ely Creek acid mine drainage abatement projects were designed in 2010 and completed in 2011, with a combined project cost of $465,000 (2014 dollars). More than 60 percent of these funds directly supported local businesses. Including secondary effects, these projects supported an estimated 2.3 total job-years; $118,000 in labor income; $175,000 in value added; and $427,000 in economic output in the local economy. Expanding to include both local and nonlocal expenditures, this project supported an estimated 7.1 total job-years; $455,000 in labor income; $655,000 in value added; and $1,236,000 in economic output in the national economy.

Acid Mine Drainage Abatement

Total project expenditures: $465,000

National economic impacts:
- 7.1 job-years
- $455,000 in labor income
- $655,000 in value added
- $1,236,000 in economic output

Local project expenditures: $290,000

Local economic impacts:
- 2.3 job-years
- $118,000 in labor income
- $175,000 in value added
- $427,000 in economic output

Economic Impacts of Restoration at the Crab Orchard National Wildlife Refuge

An egret flying over Crab Orchard National Wildlife Refuge. Photo credit: U.S. Fish and Wildlife Service.

The Crab Orchard National Wildlife Refuge (Crab Orchard NWR) located in southern Illinois is a refuge for humans and wildlife alike, and has a unique history of industry, employment, and restoration. In 1936, the Resettlement Administration of the U.S. Department of Agriculture purchased land along Crab Orchard Creek to establish the Crab Orchard Lake reservoir as part of a Great Depression era reemployment program. During World War II, the War Department established the Illinois Ordnance Plant on the site to manufacture ammunition and bombs. In 1947, following the war, the land was transferred into the National Wildlife Refuge System. The enabling legislation for the Crab Orchard NWR required the U.S. Fish and Wildlife Service (FWS) to reuse some of the Army facilities for industry and use other areas of the refuge for agriculture, recreation, and wildlife conservation. Today, the Crab Orchard NWR has among the highest outdoor recreation and wildlife dependent human uses in the National Wildlife Refuge System, as well as an active agricultural program that includes row crop production, hay production, and cattle grazing.

The industrial uses of the site by the Army and subsequent tenants released hazardous contaminants into the environment. In 1987, because of extensive environmental contamination, the industrial complex was designated as a Superfund site and placed on the U.S. Environmental Protection Agency's (EPA's) National Priorities List. The FWS was designated as the lead agency for remediation, and the agency coordinated remediation efforts with the EPA, the Illinois Environmental Protection Agency, and the U.S. Army Corps of Engineers (USACE). The USACE was designated as the lead agency for areas identified as Formerly Used Defense Sites, that is, the areas that were used during World War II. Remediation and restoration efforts have been underway for more than two decades, and several sites have been investigated and cleaned up by potentially responsible parties. To date, approximately $150 million has been spent on remediation and restoration activities, including the excavation and (or) treatment of more than 300,000 cubic yards of soil and sediment containing polychlorinated biphenyls (PCBs), heavy metals, explosives, pesticides, and solvents; and the treatment of groundwater contaminated with solvents. It is anticipated that groundwater treatment will need to continue for decades to achieve the required groundwater standards (U.S. Environmental Protection Agency, 2014). As a result of cleanup efforts, more than 140 acres have been reforested and PCB concentrations in fish in Crab Orchard Lake have declined significantly. These remediation and restoration efforts have improved fish and wildlife habitats, water quality in Crab Orchard Lake, and recreational opportunities such as fishing, boating, bird watching, camping, and swimming.

This report highlights two restoration projects on the Crab Orchard NWR: the remediation and restoration of an industrial wastewater treatment facility, and the restoration of 62 acres of the refuge to native prairie. The U.S. Geological Survey collected data on restoration activities and expenditures to estimate the economic activity supported by these restoration projects.

Background information on the Crab Orchard Natural Resource Damage Assessment and Restoration (NRDAR) settlement was obtained from Leanne Moore, U.S. Fish and Wildlife Service Environmental Remediation and Restoration Program, written commun., 2015; and from Crab Orchard NRDAR case documents at http://www.cerc.usgs.gov/orda_docs/CaseDetails?ID=1004.

Wastewater Treatment Plant Remediation and Restoration

Background information.— Site 36, the wastewater treatment plant on the Crab Orchard National Wildlife Refuge (Crab Orchard NWR), is one of 21 sites on the refuge that have been remediated. The wastewater treatment plant, which was constructed as part of the Illinois Ordnance Plant in 1942, was used to treat wastewater from industrial tenants until the spring of 2005. Through a series of drainages, the outfall from the plant eventually discharged into Crab Orchard Lake. The wastewater treatment plant and surrounding area, which covers approximately 50 acres, became contaminated with hazardous substances, such as polychlorinated biphenyls, heavy metals, pesticides, and dioxins. The U.S. Fish and Wildlife Service (FWS), in collaboration with the U.S. Environmental Protection Agency; the U.S. Army Corps of Engineers; the Bureau of Reclamation; and Pangea Group, a Missouri-based construction, environmental, and engineering firm, cleaned up and restored Site 36 for protection of human health and the environment and wildlife use.

Demolition of the wastewater treatment plant.
Photo credit: U.S. Fish and Wildlife Service.

Removal of contaminated soil.
Photo credit: U.S. Fish and Wildlife Service.

The cleanup of Site 36 included demolition of the wastewater treatment plant; onsite treatment of impounded water; excavation and offsite disposal of 47,786 cubic yards of contaminated soil, sediment, and sludge in a permitted landfill; backfilling with clean soil; and regrading. To restore the site for wildlife habitat, the upland area was reforested with hardwood native trees. The reforested area is contiguous to large tracts of forested land, and the expanded forested area is particularly beneficial for neotropical migrant songbirds. Maintenance of the restoration site is ongoing; the FWS is working to control invasive and exotic plant species that harm native vegetation and wildlife habitat, and the agency will continue to monitor the performance of the restoration until groundwater quality is restored.

Background information on the Crab Orchard Site 36 wastewater treatment plant remediation and restoration was obtained from Leanne Moore, U.S. Fish and Wildlife Service Environmental Remediation and Restoration Program, written commun., 2015; and from Crab Orchard Natural Resource Damage Assessment and Restoration case documents at http://www.cerc.usgs.gov/orda_docs/CaseDetails?ID=1004.

Economic impacts.—Planning and design of the Site 36 wastewater treatment plant remediation and restoration project began in 1991. Project implementation began in 2005 and was completed in 2009. The project was funded by appropriations from Congress and the U.S. Department of the Interior's (DOI's) Central Hazardous Materials Fund, which was created to support cleanup of contaminated sites on DOI lands. The total cost of the project was $9,101,000 (2014 dollars). An estimated 35 percent of project expenditures was spent within the local economy near the Crab Orchard NWR. These local expenditures supported an estimated 32.4 job-years; $1,791,000 in labor income; $3,002,000 in value added; and $4,737,000 in economic output in the local area economy. Expanding to include both local and nonlocal expenditures, the Site 36 wastewater treatment plant remediation and restoration project supported an estimated total of 139.4 job-years; $8,789,000 in labor income; $13,242,000 in value added; and $21,781,000 in economic output in the national economy.

Site 36 Remediation and Restoration

Total project expenditures: $9,101,000

National economic impacts:
- 139.4 job-years
- $8,789,000 in labor income
- $13,242,000 in value added
- $21,781,000 in economic output

Local project expenditures: $3,162,000

Local economic impacts:
- 32.4 job-years
- $1,791,000 in labor income
- $3,002,000 in value added
- $4,737,000 in economic output

Prairie Restoration

Background information.—In the late 1800s through the early 1900s, nearly all of the area that is now the Crab Orchard National Wildlife Refuge (Crab Orchard NWR) was either logged for timber or cleared and converted to other uses, particularly agriculture. By the 1930s, soils in the area were depleted and severely eroded. Additional clearing and development ensued with the establishment of the Illinois Ordnance Plant during World War II.

Refuge staff applying a prescribed burn treatment. Photo credit: U.S. Fish and Wildlife Service.

In 2014, as part of the effort to restore Crab Orchard NWR lands to benefit wildlife, the refuge undertook the Hampton native prairie restoration project to convert a 62-acre nonnative cool-season hay field into a native warm-season grassland. The primary benefit of this restoration is higher quality habitat for grassland-dependent wildlife species, such as migratory birds—particularly those identified by the U.S. Fish and Wildlife Service as nongame species of management concern: the loggerhead shrike (*Lanius ludovicianus*) and grasshopper sparrow (*Ammodramus savannarum*). By increasing pollinator habitat, this restoration will also promote conservation of pollinator species, such as the monarch butterfly (*Danaus plexippus*). A secondary benefit of the restoration is increased forage availability for cattle. Ongoing maintenance will control weedy species and promote diversity of native grasses and forbs by rotational cattle grazing, prescribed fire, and mowing.

Background information on the Crab Orchard prairie restoration was obtained from Casey Bryan, Crab Orchard National Wildlife Refuge, written commun., 2015; and from Crab Orchard Natural Resource Damage Assessment and Restoration case documents at http://www.cerc.usgs.gov/orda_docs/CaseDetails?ID=1004.

A pearl crescent butterfly, one of many pollinators, enjoying the newly restored prairie. Photo credit: U.S. Fish and Wildlife Service.

Milkweed provides habitat and food for Monarch butterflies.
Photo credit: U.S. Fish and Wildlife Service.

Economic impacts.—The Hampton prairie restoration was funded by the Crab Orchard NWR Natural Resource Damage Assessment. Settlement funds paid for native seed, site preparation and materials, and some labor. Additional labor costs for prescribed fire activities were provided by the Crab Orchard NWR. The initial phase of the Hampton prairie restoration took place in 2014 and cost $42,000 (2014 dollars). Approximately 41 percent of project expenditures was made within the local economy, which supported 0.5 job-years; $17,000 in labor income; $18,000 in value added; and $28,000 in local economic output. Expanding to include the effects of both local and nonlocal expenditures, the Hampton prairie restoration project supported an estimated total of 0.9 job-years; $46,000 in labor income; $75,000 in value added; and $143,000 in economic output in the national economy.

Hampton Native Prairie Restoration

Total project expenditures: $42,000

National economic impacts:
- 0.9 job-years
- $46,000 in labor income
- $75,000 in value added
- $143,000 in economic output

Local project expenditures: $17,000

Local economic impacts:
- 0.5 job-years
- $17,000 in labor income
- $18,000 in value added
- $28,000 in economic output

Economic Impacts of Restoring the California Gulch Superfund Site

Leadville, located in the mountains of Colorado approximately 100 miles west of Denver, was historically a rich mining district. Silver, gold, copper, zinc, manganese, and lead were all mined in the area beginning in the mid-1800s, but mining has since subsided as the main economic driver for the district. Because of environmental contamination from mining activities, the area known as the California Gulch Superfund site was placed on the U.S. Environmental Protection Agency's (EPA's) National Priorities List in September 1983. The site covers approximately 18 square miles in and around Leadville, Colorado, and contains thousands of piles of mine waste and drainage sites that discharge into the California Gulch from underground abandoned mines. The EPA began emergency remediation at the site in 1986 and remediation continues to this day. In 2006, on behalf of the public, the Natural Resource Trustees (Trustees), which include U.S. Department of the Interior agencies and the State of Colorado, estimated damages to natural resources at the California Gulch Superfund site. The Trustees determined that the release of hazardous substances from the site, including heavy metals and acid, have resulted in injuries to groundwater and aquatic and terrestrial resources. Injured terrestrial resources include upland areas associated with mine waste deposits and floodplain areas with contaminated riparian zones, irrigated meadows, and fluvial deposits. Surface water in California Gulch has been observed to exceed the adverse effects thresholds for aquatic biota for zinc, cadmium, and other metals, and these high metal concentrations have resulted in nearly a complete loss of some biological communities (Stratus Consulting Inc., 2010).

A 2008 Natural Resource Damage Assessment settlement agreement requires the Resurrection Mining Company and Newmont USA Limited to pay $10.5 million in damages for injured natural resources resulting from the discharge of hazardous substances from the California Gulch Superfund site. Additionally, the 2009 ASARCO LLC bankruptcy resulted in a $10 million, plus interest, settlement to the Trustees. These settlement funds were used for many restoration projects in and around Leadville, Colorado, including the Arkansas Instream Habitat Restoration Project, the Canterbury Tunnel Project, and the Dinero Tunnel Project. A great deal of progress has been made as a result of these and other restoration projects in the area and, as of 2014, 70 percent of the site had been delisted from the EPA's National Priority List. The U.S. Geological Survey collected data on restoration activities and expenditures to estimate the economic activity supported by these restoration projects.

Background information on the California Gulch Superfund site was obtained from Laura Archuleta, U.S. Fish and Wildlife Service, written commun., 2015; and from Natural Resource Damage Assessment and Restoration case documents at http://www.cerc.usgs.gov/orda_docs/CaseDetails?ID=37.

Arkansas River Instream Habitat Restoration

Background information.—Settlement funds from the California Gulch Superfund site have been used to improve instream aquatic habitat and increase brown trout (*Salmo trutta*) populations in the Arkansas River. The upper Arkansas River Basin is a high-elevation mountain river that supports trout populations. Historically characterized by a relatively narrow channel with fast moving water, recent degradation of the upper Arkansas River due to historic land-use practices have contributed to an altered river channel and a decrease in important habitat features for trout, such as deep-water pools. This restoration project was designed to address three major issues: bank erosion, altered river channel morphology, and degraded instream trout habitat. Led by the U.S. Fish and Wildlife Service, who partnered with the Colorado Parks and Wildlife Commission, the Lake County Conservation District, and Colorado Mountain College, restoration has taken place on both public and private land along an 11-mile reach of the Arkansas River and in the Lake Fork Watershed. Project treatments included modification of the river channel morphology, reduction of channel width, excavation of instream pools, elevation of the river-bottom, construction of riparian benches to extend the width of important riparian zones, in-channel placement of boulders and other debris, and planting and reseeding riparian vegetation along the streambanks. Woody debris and boulders were added to stabilize streambanks and reduce erosion by slowing water flows at the water-bank interface. Livestock fencing was installed and grazing management plans developed to promote rotational grazing near the river corridor. This project is ongoing, but has already been deemed an enormous success. As a result of this project and other restoration efforts in the area, the Colorado Parks and Wildlife Commission announced in 2014 that the Upper Arkansas River was added to the Statewide list of Gold Medal Trout Waters, a designation given only to the top locations in the State for trout fishing.

Background information on the Arkansas River instream habitat restoration was obtained from Laura Archuleta, U.S. Fish and Wildlife Service, Greg Brunjak, Lake County Conservation District, and Tracy Kittell, Colorado Parks and Wildlife, written commun., 2015; and from California Gulch Superfund site Natural Resource Damage Assessment and Restoration case documents at http://www.cerc.usgs.gov/orda_docs/CaseDetails?ID=37.

Before and after photos of sand bar reconstruction and bank stabilization to restore fish, wildlife and invertebrate habitat on the upper Arkansas River. Photo credit: Tracy Kittell, Colorado Parks and Wildlife.

Economic impacts.—The Arkansas River Instream Habitat Restoration project began in 2010 and continued into 2014, and had a total cost of more than $3,244,000 during this period (2014 dollars). Approximately 54 percent of the funds for this project was spent locally, which supported an estimated total of 25.0 job-years; $1,268,000 in labor income; $1,667,000 in value added; and $3,261,000 in economic output within the local economy surrounding the project site. Expanding to include the effects of both local and nonlocal expenditures, the Arkansas River Instream Habitat Restoration project supported an estimated total of 49.5 job-years; $3,119,000 in labor income; $4,600,000 in value added; and $9,060,000 in economic output to the national economy.

Arkansas River Instream Habitat Restoration

Total project expenditures: $3,244,000

National economic impacts:
- 49.5 job-years
- $3,119,000 in labor income
- $4,600,000 in value added
- $9,060,000 in economic output

Local project expenditures: $1,763,000

Local economic impacts:
- 25.0 job-years
- $1,268,000 in labor income
- $1,667,000 in value added
- $3,261,000 in economic output

Canterbury Tunnel Project

Background information.—The original Canterbury Tunnel began as an idea in 1922 as a way to remove excess water in the mines that honeycomb the mountains near Leadville, Colorado. The objective behind reducing the volume of water in these mines was to increase the opportunity for ore extraction. The project's original plans were never fully realized because of technological limitations and increasingly dangerous conditions that confronted workers, and so the 4,000-foot-long Canterbury Tunnel sat dormant until the early 1960s. Historically, Leadville relied on the nearby Big Evans Reservoir as the main source of municipal water. The reservoir's elevation of 10,200 feet above sea level was especially problematic for Leadville during the cold Colorado winters because the cold water regularly caused pipes throughout the town to freeze.

In 1962, Leadville learned that the water draining out of the Canterbury Tunnel was not only clean, but it was also at a temperature of more than 50 ºF. The town decided to invest in piping and a pump station so the relatively warm water flowing from the Canterbury Tunnel could be used to supplement the town's municipal water system and help reduce the problem of frozen pipes.

By the early 1990s, the original Canterbury Tunnel began to show signs of stress. The timbers used as support structures for the tunnel's original construction in the 1920s began to rot and collapse causing cave-ins and blocking the water flow. By 2003, the water source flowing from the tunnel could no longer be used, which resulted in water shortages and a stressed distribution system during the winter months. In response to these shortages, the Parkville Water District in Leadville elected to re-drill and intersect the original Canterbury Tunnel above the collapsed areas that were restricting the flow of the warm water. Funds for the project came from the Colorado Department of Local Affairs, the settlement from the California Gulch Superfund site, and the Parkville Water District. Components of this project included drilling and intersecting the passageway above the tunnel's blockage, building a new pump station, and laying an additional 8,200-foot pipe to the Big Evans Water Treatment Plant, which expanded the distribution of the relatively warm water to other parts of the municipal system that were historically bypassed by the tunnel's original design. The project was completed in November 2012, and resulted in an average increase of 10 ºF in water temperature throughout the distribution system. As a result of this project, 2012 marked the first year on record where Leadville's water distribution system did not experience frozen lines during the winter months.

Greg Teter, the Parkville Water District General Manager, checks the water treatment plant's monitoring system that is now supplied by flows from the Canterbury Tunnel. Photo credit: Kathy Bedell, Leadville Today.

Background information on the Canterbury Tunnel project was obtained from Laura Archuleta, U.S. Fish and Wildlife Service, and Greg Teter, Parkville Water District, written commun., 2015; and from California Gulch Superfund site Natural Resource Damage Assessment and Restoration case documents at http://www.cerc.usgs.gov/orda_docs/CaseDetails?ID=37.

Economic impacts.—The Canterbury Tunnel project was conducted in 2012, and had a total cost of more than $1,674,000 (2014 dollars). Approximately 52 percent of project funds was spent locally, which supported an estimated 8.6 job-years; $516,000 in labor income; $769,000 in value added; and $1,702,000 in economic output within the local economy near the project site. Expanding to include both local and nonlocal expenditures, this project supported an estimated total of 21.6 job-years; $1,461,000 in labor income; $2,325,000 in value added; and more than $4,462,000 in economic output in the national economy.

Canterbury Tunnel Project

Total project expenditures: $1,674,000

National economic impacts:
- 21.6 job-years
- $1,461,000 in labor income
- $2,325,000 in value added
- $4,462,000 in economic output

Local project expenditures: $867,000

Local economic impacts:
- 8.6 job-years
- $516,000 in labor income
- $769,000 in value added
- $1,702,000 in economic output

Dinero Tunnel Acid Mine Drainage Pathway Elimination Project

Background information.—The Dinero Tunnel, which extends approximately 3,000 feet from the surface to the Dinero Shaft, was used in the late 1800s to mine primarily for silver. In more recent years, the tunnel, located approximately five miles west of Leadville, Colorado, began to discharge acid mine drainage into Sugarloaf Gulch, a tributary to the Lake Fork River which ultimately drains into the upper Arkansas River. Consequently, acid mine drainage from the Dinero Tunnel has significantly affected downstream waters, including a wet meadow and beaver pond complex. Occasionally, the Dinero Tunnel experienced blowouts that developed when temporary pressure would build up behind a blockage in the tunnel, which would then expel sludge and rocks and increase the risk of acid mine drainage further downstream.

In response to these conditions, settlement funds from the California Gulch Superfund site have been utilized to support the Dinero Tunnel Acid Mine Drainage Pathway Elimination Project. For this project, the U.S. Fish and Wildlife Service partnered with the Bureau of Land Management (BLM) and the Colorado Division of Reclamation, Mining and Safety. Although the tunnel is located on private land, the BLM led the cleanup because of identified impacts on adjacent and downstream land managed by that agency.

The Dinero Tunnel Acid Mine Drainage Pathway Elimination Project addressed problematic acid mine drainage through the installation of a concrete bulkhead deep inside the tunnel. The idea behind the bulkhead was to reduce the volume of acid mine drainage and the risk of blowout events from the tunnel. The steel reinforced concrete bulkhead, which was installed 1,250 feet from the opening of the Dinero Tunnel, is equipped with a valve to allow for adjustments of water level within the tunnel. Following installation of the bulkhead, there exists the possibility that water from the tunnel may surface uphill of the tunnel opening. However, it is expected that the water will be of good quality because the metals that are generated in the upper portion of the mine pool tend to stratify to the bottom and movement of water within the mine pool is expected to occur above the sulfide ore zones (Stratus Consulting Inc., 2009).

Background information on the Dinero Tunnel Acid Mine Drainage Pathway Elimination Project was obtained from Laura Archuleta, U.S. Fish and Wildlife Service, and Craig Bissonnette, Colorado Division of Reclamation, Mining, and Safety, written commun., 2015; and from California Gulch Superfund site Natural Resource Damage Assessment and Restoration case documents at http://www.cerc.usgs.gov/orda_docs/CaseDetails?ID=37.

Economic impacts.—The Dinero Tunnel Acid Mine Drainage Pathway Elimination Project began in 2006 and continued through 2014, and had a total cost of nearly $1,294,000 during this period (2014 dollars). Approximately 9 percent of all project expenditures was made within the local area. These expenditures supported an estimated 2.0 job-years; $117,000 in labor income; $127,000 in value added; and $206,000 in economic output within the local economy near the project site. Expanding to include the effects of both local and nonlocal expenditures, funds from the Dinero Tunnel Acid Mine Drainage Pathway Elimination Project supported an estimated total of 24.3 job-years; $1,472,000 in labor income; $1,988,000 in value added; and $3,767,000 in economic output in the national economy.

Dinero Tunnel Acid Mine Drainage Pathway Elimination Project

Total project expenditures: $1,294,000

National economic impacts:
- 24.3 job-years
- $1,472,000 in labor income
- $1,988,000 in value added
- $3,767,000 in economic output

Local project expenditures: $118,000

Local economic impacts:
- 2.0 job-years
- $117,000 in labor income
- $127,000 in value added
- $206,000 in economic output

Economic Impacts of Sagebrush Steppe Restoration in BLM's Color Country

Characterized by vast acres of sagebrush and pinyon-juniper clad foothills, the Bureau of Land Management's (BLM's) Color Country District, located in southern Utah, is home to a variety of species, including greater sage-grouse (*Centrocercus urophasianus*), Utah prairie dog (*Cynomys parvidens*), mule deer (*Odocoileus hemionus*), antelope (*Antilocapra americana*), elk (*Cervus elaphus*), and wild horses (*Equus ferus*). These species depend on the sagebrush steppe ecosystem historically present in this region. Starting in the late 1800s with the Euroamerican settlement of the west, the sagebrush steppe ecosystem has been rapidly changing into woodlands of western juniper (*Juniperus occidentalis*) and pinyon (Blank and others, 2008). This transition from sagebrush and perennial grasses to a landscape dominated by trees has decreased the available habitat for sagebrush-dependent species such as sage-grouse and mule deer. The change to a wooded landscape has also dramatically increased fire risk, which further increases the risk of habitat loss, as well as human infrastructure loss.

The BLM and other Federal, State, and local government agencies; nongovernmental organizations; and many sportsmen and wildlife groups have teamed up to restore and manage priority ecosystems within Utah, the Colorado Plateau, and the Great Basin. Through Utah's Watershed Restoration Initiative (WRI), these organizations are partnering to pool resources and to restore healthy landscapes at a watershed scale. Through multi-phase and multi-year large-scale vegetation treatments, WRI partners are providing better wildlife habitat, restoring critical watersheds, and reducing the risk of wildfire to urban communities. To date, WRI partners have restored more than 1.1 million acres in Utah.

To restore wildlife habitat and reduce fire risk, BLM is removing pinyon and juniper trees to open wildlife travel corridors and provide firebreaks. BLM is also managing for invasive species, and seeding perennial grasses, forbs, and shrubs to reestablish sagebrush steppe vegetation. The methods used to accomplish this work include a variety of management tools, such as hand thinning, mechanical treatments, prescribed fire, herbicide treatments, and aerial seeding. By removing encroaching trees and establishing desired understory vegetation, these restoration projects maintain and enhance the long-term resilience of restored landscapes.

Removing encroaching pinyon and juniper stands to reduce wildfire risk along the wildland-urban interface. Photo credit: BLM.

The U.S. Geological Survey collected data on restoration activities and expenditures to estimate the economic activity supported by restoration activities on four priority restoration areas in the BLM Color Country District: South Canyon, Duncan Creek, South Beaver, and Upper Kanab Creek. Based on the economic impacts estimated for these four restoration projects, it is estimated that, on average, every $1 million spent on watershed restoration in Utah generates 17.4 job-years; $1,028,000 in labor income; $1,316,000 in value added; and $2,440,000 in economic output in the Western States economy. Between 2011 and 2014, BLM spent a total of $15,730,000 (an average of $3,932,500 per year) on similar watershed restoration projects in the Color Country district. Based on the estimated average impacts per $1 million for these types of restoration projects, BLM Color Country watershed restoration projects supported an estimated 68 job-years; $4,000,000 in labor income; $5,200,000 in value added; and $9,600,000 in economic output in the Western States economy each year.

Greater sage-grouse at South Canyon.
Photo credit: BLM.

It is important to note that the economic value of these restoration projects encompasses more than the economic activity generated through project expenditures. These restoration projects also provide substantial economic values through ecosystem services that directly and indirectly affect human welfare. These projects restore and maintain important habitat for mule deer, a popular big-game species, and thus enhance wildlife-based recreation opportunities in the region. Additionally, restored sagebrush habitat is critical for the conservation of the greater sage-grouse, a species of high conservation priority. The removal of pinyon and juniper trees from the landscape also greatly reduces fire risk, thus providing additional economic value by reducing the probability of fire along the wildland-urban interface.

Background information on the BLM Color Country restoration projects was obtained from Vicki Tyler, BLM Color Country District, written commun., 2015; and from the WRI Website at https://wri.utah.gov/wri/.

South Canyon Restoration

Background information.—The South Canyon project area consists of 121,000 acres within the Upper Sevier River Watershed in southern Utah. This watershed is ranked as high priority for restoration because of degraded riparian and upland vegetation and erosion, the presence of hazardous fuels placing communities at increased risk of wildfire, and degraded greater sage-grouse (*Centrocercus urophasianus*) and mule deer (*Odocoileus hemionus*) habitat because of the expansion and infilling of pinyon and juniper. In particular, this project was designed to reestablish and maintain sagebrush semi-desert habitat, open travel corridors, and provide benefits to sage-grouse and mule deer within and immediately adjacent to the project area.

A bullhog removing pinyon and juniper trees. Photo credit: BLM.

Restoration in this area is ongoing; this case study focuses on restoration activities that occurred between 2009 and 2013. During this period, restoration was accomplished on 5,929 acres of public and private lands. The project was funded by a variety of private, State, and Federal cooperators, including the Bureau of Land Management (BLM) and the U.S. Department of Agriculture's Natural Resources Conservation Service.

Background information on the BLM Color Country South Canyon restoration project was obtained from Vicki Tyler, BLM Color Country District, written commun., 2015; and from the Watershed Restoration Initiative Website at https://wri.utah.gov/wri/.

Economic impacts.—Total expenditures for this project were $3,546,000 (2014 dollars), with an estimated 34 percent of these expenditures spent within the local economy (Beaver, Garfield, Iron, Kane, and Washington Counties in Utah). Local expenditures supported an estimated 14.7 job-years; $855,000 in labor income; $1,202,000 in value added; and $2,029,000 in economic output within the local economy. Many of the contractors that worked on the project are located outside of the local area. Including the impacts associated with all project expenditures, the South Canyon Restoration Project supported an estimated 59.8 job-years; $3,616,000 in labor income; $4,629,000 in value added; and $8,755,000 in economic output in the Western States economy.

South Canyon Restoration

Acres restored: 5,929
Total project expenditures: $3,546,000

Western States economic impacts:
- 59.8 job-years
- $3,616,000 in labor income
- $4,629,000 in value added
- $8,755,000 in economic output

Local project expenditures: $1,194,000

Local economic impacts:
- 14.7 job-years
- $855,000 in labor income
- $1,202,000 in value added
- $2,029,000 in economic output

Duncan Creek Restoration

Aerial seeding of native grasses and forbs. Photo credit: BLM.

Background information.—The Duncan Creek restoration area is located in Iron County, Utah. This area provides important habitat for mule deer (*Odocoileus hemionus*), and an increasing number of homes are located in the wildland-urban interface. Restoration efforts are focused on both habitat improvement and fire/fuels reduction.

Restoration in this area is ongoing; this case study focuses on restoration activities that occurred primarily in 2012. During this period, restoration was accomplished on 2,080 acres of public and private lands. The project was funded by a variety of private, State, and Federal cooperators, including the Bureau of Land Management (BLM), Mule Deer Foundation, National Wild Turkey Federation, and Sportsmen for Fish and Wildlife.

Background information on the BLM Color Country Duncan Creek Restoration project was obtained from Vicki Tyler, BLM Color Country District, written commun., 2015; and from the Western Restoration Initiative Website at https://wri.utah.gov/wri/.

Economic impacts.—Total expenditures for this project were $1,039,000 (2014 dollars), with an estimated 37 percent of these expenditures spent within the local economy (Beaver, Garfield, Iron, Kane, and Washington Counties in Utah). Local expenditures supported an estimated 5.0 job-years; $284,000 in labor income; $367,000 in value added; and $692,000 in economic output within the local economy. Many of the contractors that worked on the project are located outside of the local area. Including the impacts associated with all project expenditures, the Duncan Creek Restoration Project supported an estimated 18.4 job-years; $1,051,000 in labor income; $1,372,000 in value added; and $2,624,000 in economic output in the Western States economy.

Duncan Creek Restoration

Acres restored: 2,080
Total project expenditures: $1,039,000

Western States economic impacts:
- 18.4 job-years
- $1,051,000 in labor income
- $1,372,000 in value added
- $2,624,000 in economic output

Local project expenditures: $387,000

Local economic impacts:
- 5.0 job-years
- $284,000 in labor income
- $367,000 in value added
- $692,000 in economic output

South Beaver Restoration

Background information.—The South Beaver area encompasses 145,000 acres in Beaver County in southern Utah and contains public, State, and private lands. The area is crucial mule deer (*Odocoileus hemionus*) winter habitat and it contains important elk (*Cervus elaphus*) habitat and occupied sage-grouse (*Centrocercus urophasianus*) habitat (U.S. Fish and Wildlife Service, 2013). Nearby population growth and the construction of Interstate 15 have increased the importance of this area for wildlife, but encroachment of pinyon and juniper have nearly eliminated any possible use of this area by sage-grouse and greatly reduced the amount of sagebrush and other forage available for deer and elk.

Restoration in this area is ongoing; this case study focuses on restoration activities that occurred between 2006 and 2011. During this period, restoration was accomplished on 7,217 acres of public and private lands. The project was funded by a variety of private, State, and Federal cooperators, including the Bureau of Land Management (BLM); Mule Deer Foundation; Sportsmen for Fish and Wildlife; Utah Division of Forestry, Fire and State Lands; and Utah Division of Wildlife Resources.

Background information on the BLM Color Country South Beaver restoration project was obtained from Vicki Tyler, BLM Color Country District, written commun., 2015; and from the Western Restoration Initiative Website at https://wri.utah.gov/wri/.

South Beaver before and after restoration. Photo credit: BLM.

Economic impacts.—Total expenditures for this project were $3,491,000 (2014 dollars) with an estimated 72 percent of these expenditures spent within the local economy (Beaver, Garfield, Iron, Kane, and Washington Counties in Utah). Local expenditures supported an estimated 37.2 job-years; $1,993,000 in labor income; $2,536,000 in value added; and $4,243,000 in economic output within the local economy. Many of the contractors that worked on the project are located outside of the local area. Including the impacts associated with all project expenditures, the South Beaver Restoration Project supported an estimated 59.4 job-years; $3,508,000 in labor income; $4,635,000 in value added; and $7,838,000 in economic output in the Western States economy.

South Beaver Restoration

Acres restored: 7,217
Total project expenditures: $3,491,000

Western States economic impacts:
- 59.4 job-years
- $3,508,000 in labor income
- $4,635,000 in value added
- $7,838,000 in economic output

Local project expenditures: $2,505,000

Local economic impacts:
- 37.2 job-years
- $1,993,000 in labor income
- $2,536,000 in value added
- $4,243,000 in economic output

Upper Kanab Creek Restoration

Deer utilizing a treated area. Photo credit: BLM.

Background information.—The Upper Kanab Creek project area encompasses 130,000 acres in southern Utah. This project area receives national attention because it is home to the Paunsagunt mule deer herd that is prized by trophy hunters, and because it supports the southernmost population of greater sage-grouse (*Centrocercus urophasianus*) within the western United States. To provide landscape level benefits for sage-grouse, this project focused on collaboration between private landowners, the U.S. Department of Agriculture's Natural Resources Conservation Service (NRCS), and Utah's Watershed Restoration Initiative to conduct treatments that cross jurisdictional boundaries. Telemetry data show that sage-grouse are actively using older treatment areas, and newer treatments will expand both winter and brood rearing habitat near the known occupied habitat.

Restoration in this area is ongoing; this case study focuses on restoration activities that occurred between 2010 and 2013. During this period, restoration was accomplished on 3,912 acres of public and private lands. The project was funded by a variety of private, State, and Federal cooperators, including the Bureau of Land Management (BLM), NRCS, Kane County Conservation District, Arizona Game and Fish Department, and the U.S. National Park Service.

Background information on the BLM Color Country Upper Kanab Creek restoration project was obtained from Vicki Tyler, BLM Color Country District, written commun., 2015; and from the Western Restoration Initiative Website at https://wri.utah.gov/wri/.

Economic impacts.—Total expenditures for this project were $1,026,000 (2014 dollars), with an estimated 38 percent of these expenditures spent within the local economy (Beaver, Garfield, Iron, Kane, and Washington Counties in Utah). Local expenditures supported an estimated 5.0 job-years; $280,000 in labor income; $359,000 in value added; and $666,000 in economic output within the local economy. Many of the contractors that worked on the project are located outside of the local area. Including the impacts associated with all project expenditures, the Upper Kanab Creek restoration project supported an estimated 18.1 job-years; $1,103,000 in labor income; $1,344,000 in value added; and $2,587,000 in economic output in the Western States economy.

Upper Kanab Creek Restoration

Acres restored: 3,912
Total project expenditures: $1,026,000

Western States economic impacts:
- 18.1 job-years
- $1,103,000 in labor income
- $1,344,000 in value added
- $2,587,000 in economic output

Local project expenditures: $391,000

Local economic impacts:
- 5.0 job-years
- $280,000 in labor income
- $359,000 in value added
- $666,000 in economic output

Southern Nevada Public Lands Management Act Projects

Steptoe Valley Weed Inventory, Education, and Treatment

View of the Steptoe Valley in eastern Nevada. Photo credit: Julie Thompson, Eastern Nevada Landscape Coalition.

Background information.— Noxious and invasive weeds can destroy wildlife habitat, reduce opportunities for recreational activities, decrease plant and animal diversity, and cause loss of productivity for private landowners. The Bureau of Land Management (BLM) Ely Field Office was awarded funding for the Steptoe Valley Weed Inventory, Education, and Treatment Project through the Southern Nevada Public Lands Management Act, which allows the U.S. Department of the Interior to utilize revenue from the sale of Federal land in Nevada for restoration projects. The objective of this project was to assist the Steptoe Valley Cooperative Weed Management Area in conducting a noxious weed inventory and providing treatment, education, and outreach on both public and private land throughout the Steptoe Valley in eastern Nevada. The Ely Field Office collaboratively worked on this project with the Eastern Nevada Landscape Coalition (ENLC), the U.S. Forest Service, and Tri-County Weed Control. To develop a greater understanding of the noxious and invasive weeds in the area, crews completed an inventory of noxious and invasive weeds on 644,837 acres of public land throughout the Steptoe Valley watershed. Crews then completed weed treatments on 4,000 acres of infested land using both chemical herbicide applications and mechanical removal. Many sites with identified infestations were then monitored during multiple field seasons to ensure treatment success. Community outreach workshops, designed to increase awareness of weeds and effectiveness of treatments, were also conducted so that landowners would be better equipped to prevent the spread of noxious weeds. This project also presented the opportunity to research different weed treatment methods available for the most prevalent weed species in the Steptoe Valley: hoary cress (*Lepidium draba*). Outcomes of this project provided the BLM, the ENLC, and the public with more effective treatment techniques, especially with respect to hoary cress; better working relationships with private landowners; reduced weed infestations; and improved and more diverse vegetation communities.

The U.S. Geological Survey collected data on restoration activities and expenditures to estimate the economic activity supported by this project. Background information on the Steptoe Valley project was obtained from Chris McVicars, BLM, written commun., 2015; and the BLM's Website at http://www.blm.gov/nv/st/en/snplma/snplma_prephase_1.html.

Economic Impacts.—Work for the Steptoe Valley Weed Inventory, Education, and Treatment Project began in 2008, concluded in 2012, and cost a total of $635,000 (2014 dollars). Approximately 95 percent of project expenditures was made locally, which supported an estimated 20.4 job-years; $678,000 in labor income; $632,000 in value added; and $1,119,000 in economic output within the local economy. Expanding to include the effects of both local and nonlocal expenditures, project funds have directly supported an estimated 20.4 job-years; $781,000 in labor income; $889,000 in value added; and $1,483,000 in economic output in the Western States economy.

> Steptoe Valley Weed Inventory, Education, and Treatment
>
> Total project expenditures: $635,000
>
> Western States economic impacts:
> - 20.4 job-years
> - $781,000 in labor income
> - $889,000 in value added
> - $1,483,000 in economic output
>
> Local project expenditures: $605,000
>
> Local economic impacts:
> - 20.4 job-years
> - $678,000 in labor income
> - $632,000 in value added
> - $1,119,000 in economic output

Pioche/Caselton Wildland-Urban Interface Project

Background information.—The Pioche/Caselton Wildland-Urban Interface Project (WUI Project) was conducted by the Bureau of Land Management's (BLM's) Ely District to reduce the threat of wildfire to the towns of Pioche and Caselton in southeastern Nevada. From 1980 to 2008, 149 wildfires were recorded near Pioche and Caselton and 9 of these fires each burned approximately 3,000 acres. In 2005, the Nevada Community Wildfire Risk/Hazard Assessment for Lincoln County determined that the risk of wildfire for the two towns was "extreme" (Resource Concepts, Inc., 2005). That report recommended implementing large fuels reduction treatments in order to reduce the risk of wildfire to Pioche and Caselton. In response, the Ely District was awarded funding for the Pioche/Caselton WUI Project from the Southern Nevada Public Lands Management Act, which allows the U.S. Department of the Interior to utilize revenue from the sale of Federal land in Nevada for restoration and capital improvement projects. The WUI Project was designed to lower the threat of wildfire to communities and infrastructure by reducing the canopy cover and fuel continuity of pinyon, juniper, and shrub species on 1,770 acres of public land. The WUI Project utilized a combination of manual and mechanical methods to reduce the fuel load within the project area, including hand thinning by chainsaw, mowing, chaining, and tree mastication. Other elements of this project include the prescribed burning of slash piles and the use of aerial seeding to promote growth of desirable grass species. Results of this project include a reduction in wildfire risk to the towns of Pioche and Caselton and a higher quality and more diverse vegetative community of forbs, grass, and shrubs across the landscape.

The U.S. Geological Survey collected data on restoration activities and expenditures to estimate the economic activity supported by this project. Background information for the Pioche/Caselton Wildland-Urban Interface Project was obtained from Kyle Teel, BLM, written commun., 2015; and the BLM's Website at http://www.blm.gov/nv/st/en/snplma/snplma_prephase_1.html.

Economic impacts.—The Pioche/Caselton WUI project began in 2012 and ran through 2013, and had a total cost $496,000 (2014 dollars). Approximately 15 percent of project expenditures was made within the local economy, which supported an estimated 1.0 job-year; $79,000 in labor income; $75,000 in value added; and $119,000 in economic output within the local economy. Expanding to include the effects both local and nonlocal expenditures, this project supported an estimated 9.7 job-years; $572,000 in labor income; $688,000 in value added; and $1,198,000 in economic output in the Western States economy.

Pioche/Caselton Wildland-Urban Interface Project

Total project expenditures: $496,000

Western States economic impacts:
- 9.7 job-years
- $572,000 in labor income
- $688,000 in value added
- $1,198,000 in economic output

Local project expenditures: $72,000

Local economic impacts:
- 1.0 job-year
- $79,000 in labor income
- $75,000 in value added
- $119,000 in economic output

Economic Impacts of the Burley Landscape Sage-Grouse Habitat Restoration

Background information.— Characterized by a vast landscape dotted with sagebrush and juniper clad foothills, the area surrounding the Bureau of Land Management's (BLM's) Burley Field Office in Idaho is home to a variety of species, such as the greater sage-grouse (*Centrocercus urophasianus*), mule deer (*Odocoileus hemionus*), antelope (*Antilocapra americana*), bighorn sheep (*Ovis canadensis*), and pygmy rabbit (*Brachylagus idahoensis*). Many of these species depend on the sagebrush steppe ecosystem that was historically present in this region. Starting in the late 1800s with the Euroamerican settlement of the west, this sagebrush steppe ecosystem has been rapidly changing into woodlands dominated by Utah juniper (*Juniperus osteosperma*) and conifers (Blank and others, 2008). This transition from sagebrush and perennial grasses to a landscape encroached by juniper trees has decreased the available habitat for sagebrush-dependent species such as sage-grouse and mule deer. The change to a wooded landscape has also dramatically increased fire risk, which further increases the risk of loss to both human infrastructure and wildlife habitat.

Mastication of juniper. Photo credit: BLM.

From 2008 through 2014, the BLM's Burley Field Office led the Burley Landscape Sage-Grouse Habitat Restoration Project to improve former sage-grouse habitat and reduce the overall fire hazard in the area. Although the majority of work for this project was completed on Federal lands, the BLM partnered with the Idaho Department of Fish and Game and Pheasants Forever to complete project treatments on adjacent state and private lands. To restore wildlife habitat and reduce fire risk, the BLM removed juniper trees to open wildlife travel corridors and provide firebreaks, and seeded perennial grasses, forbs, and shrubs to reestablish sagebrush steppe vegetation. The methods used to accomplish this work include a variety of management tools, including hand thinning, mechanical treatments, and aerial seeding. By removing encroaching trees and establishing desired understory vegetation, these restoration projects are designed to maintain and enhance the long-term resilience of restored landscapes.

The U.S. Geological Survey collected data on restoration activities and expenditures to estimate the economic activity supported by this project. Background information on the Burley Landscape project was obtained from Brandon Brown, BLM, written commun., 2015; and U.S. Department of the Interior, Bureau of Land Management, 2015.

Economic impacts.—The Burley Landscape Sage-Grouse Habitat Restoration Project began in 2008 and continued through 2014, with a total cost of $1,395,000 (2014 dollars) during this period. Approximately 18 percent of project expenditures was made locally, which supported an estimated 7.6 job-years; $301,000 in labor income; $312,000 in valued added; and $450,000 in economic output within the local economy. Expanding to include the effects of both local and nonlocal expenditures, the Burley Landscape Sage-Grouse Habitat Restoration Project has supported an estimated 41.8 job-years; $1,605,000 in labor income; $1,901,000 in value added; and $3,149,000 in economic output in the Western States economy.

Burley Landscape Sage-Grouse Habitat Restoration

Total project expenditures: $1,395,000

Western States economic impacts:
- 41.8 job-years
- $1,605,000 in labor income
- $1,901,000 in value added
- $3,149,000 in economic output

Local project expenditures: $255,000

Local economic impacts:
- 7.6 job-years
- $301,000 in labor income
- $312,000 in value added
- $450,000 in economic output

Economic Impacts of the Twin Falls District Sagebrush Restoration

Sagebrush seedlings growing in a contractor's nursery greenhouse.
Photo credit: Brandon Brown, BLM.

Background information.— The Twin Falls District of the Bureau of Land Management (BLM) has experienced an incredible increase in large-scale fires that have completely altered the fire regime across the landscape. These areas were historically a Wyoming sagebrush steppe ecosystem, but are now dominated by large areas of grasses devoid of a shrub component. This vegetation change has resulted in significant loss of sage-grouse habitat and has altered the fire return interval so the area now burns every few years rather than the historic 50- to 75- year interval (Barret and others, 2010). In response to these landscape changes, the BLM has partnered with the Idaho Department of Fish and Game (DFG) in an effort to grow and plant sagebrush seedlings throughout the Twin Falls District. Since 2009, approximately 500,000 containerized Wyoming sagebrush seedlings have been grown in greenhouse nurseries and planted by contractors, BLM staff, and community volunteers. Some of the sagebrush seedlings were grown in greenhouses owned by local public schools, which is seen as a first step in developing a small-scale production partnership that promotes educational opportunities for local students. The Idaho DFG has also completed similar projects on adjacent State lands, and has coordinated volunteer planting days for planting seedlings on BLM land as a part of this overall restoration effort. This massive, large scale, sagebrush-planting effort is intended to restore a seed source for the long-term reestablishment of sagebrush across the landscape and to change the area from a grass-fuel model to a brush-fuel model that may burn less frequently.

The U.S. Geological Survey collected data on restoration activities and expenditures to estimate the economic activity supported by this project. Background information on the Twin Falls District project was obtained from Brandon Brown, BLM, written commun., 2015; and U.S. Department of the Interior, Bureau of Land Management, 2012.

Economic impacts.—The Twin Falls District Sagebrush Restoration project began in 2009 and continued through 2014, with a total cost of $1,475,000 (2014 dollars) during this period. Approximately 54 percent of project expenditures was made locally, which supported an estimated 19.1 job-years; $660,000 in labor income; $543,000 in value added; and $1,172,000 in economic output within the local economy. Expanding to include the effects of local and nonlocal expenditures, the Twin Falls District Sagebrush project has supported an estimated 33.9 job-years; $1,808,000 in labor income; $2,008,000 in value added; and $3,772,000 in economic output in the Western States economy. Beyond these economic measures, this project also fostered community support by volunteers, and promoted educational opportunities with local school partnerships.

Twin Falls District Sagebrush Restoration

Total project expenditures: $1,475,000

Western States economic impacts:
- 33.9 job-years
- $1,808,000 in labor income
- $2,008,000 in value added
- $3,772,000 in economic output

Local project expenditures: $792,000

Local economic impacts:
- 19.1 job-years
- $660,000 in labor income
- $543,000 in value added
- $1,172,000 in economic output

Economic Impacts of Post-Wildfire Restoration in Southeast Oregon

The 2012 fire season was very active in the western United States. Fires began early in the spring in the southwest, and moved into both the intermountain and Great Basin regions by early summer. Southeast Oregon was no exception; the typical fire season in this region begins in late July, but in 2012, it began in early April with several fires burning more than 1,000 acres. Leading up to the 2012 fire season, southeast Oregon had an unusually low snowpack followed by less than normal spring rains, which resulted in very low moisture content in soil and live biomass. Dry sagebrush mixed in with stands of juniper and relatively continuous beds of dry grass dominated the landscape. These dry conditions intensified the Miller Homestead fire (160,801 acres) and the Long Draw fire (558,198 acres), both of which ignited from afternoon lightning strikes during a storm on July 8, 2012. The Miller Homestead fire burned within the Bureau of Land Management's (BLM's) Burns District, while the Long Draw fire burned primarily within the BLM's Vale District. Although the majority of land burned in these two fires came under the jurisdiction of the BLM, both fires also burned private land and lands managed by other government agencies. Both fires burned for eight to nine days before reaching their greatest extents. These two fires burned a variety of landscapes and negatively affected many resources and uses, including forage for livestock grazing, habitat for sage-grouse and other sensitive species, wild horse herd management areas, Areas of Critical Environmental Concern, and wilderness study areas.

Background information on the 2012 Southeast Oregon fires was obtained from Autumn Toelle, BLM, written commun., 2015; and Blackwood, 2013.

Burnt landscape and a damaged fence after the destruction from the Miller Homestead fire. Photo credit: Autumn Toelle. BLM.

Miller Homestead Fire Emergency Stabilization and Rehabilitation

Background information.—On July 8, 2012, lightning ignited a fire on Bureau of Land Management (BLM)-managed land on the Miller Homestead in Harney County, Oregon. High winds combined with unusually hot and dry conditions spread the fire through dry grass and sagebrush and 160,801 acres were burned before the fire was contained on July 24, 2012. In the aftermath, it was determined that ecological restoration was necessary since the majority of the fire occurred within prime habitat for sage-grouse, and the fire had burned with such severity that it removed vegetation down to bare soil. Without rehabilitation efforts, desirable vegetation would be unlikely to reestablish and the site would be open to invasion by noxious weeds. Major components of the Miller Homestead Fire Emergency Stabilization and Rehabilitation Project included the replacement of permanent and temporary fencing and wildlife guzzlers; aerial seeding; drill seeding; collecting and growing sagebrush seed for future plantings; removal of downed juniper near the community of Frenchglen, Oregon; and inventory and monitoring of noxious weeds. The goal of this project is to restore the ecological condition and function of the landscape, which, if achieved, will result in improved wildlife habitat, increased forage availability that will allow for continued livestock grazing, restored habitat for wild horses, a reduced risk of erosion, enhanced recreation opportunities, and better community protection from the risk of future wildfires.

The U.S. Geological Survey collected data on restoration activities and expenditures to estimate the economic activity supported by this project. Background information on the Miller Homestead project was obtained from Autumn Toelle, BLM, written commun., 2015; and Blackwood, 2013.

Economic impacts.—The Miller Homestead Fire Emergency Stabilization and Rehabilitation Project began in 2013 and continued into 2014, and had a total cost of $2,512,000 during this period (2014 dollars). Approximately 40 percent of project funds was spent locally, which supported an estimated total of 19.2 job-years; $709,000 in labor income; $768,000 value added; and $1,681,000 in economic output within the local economy near the fire's recovery effort. Expanding to include the effects of both local and nonlocal expenditures, the Miller Homestead Fire Emergency Stabilization and Rehabilitation Project supported an estimated 37.6 job-years; $2,014,000 in labor income; $2,968,000 in value added; and $6,645,000 in economic output in the Western States economy. The Miller Homestead Fire Emergency Stabilization and Rehabilitation Project will continue after 2014.

Miller Homestead Fire Emergency Stabilization and Rehabilitation

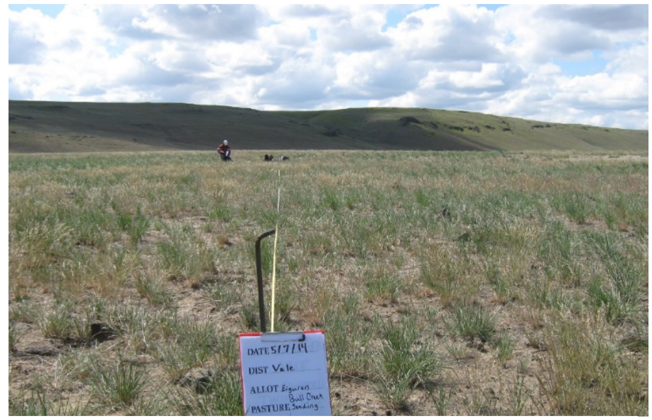
Total project expenditures: $2,512,000

Western States economic impacts:
- 37.6 job-years
- $2,014,000 in labor income
- $2,968,000 in value added
- $6,645,000 in economic output

Local project expenditures: $1,002,000

Local economic impacts:
- 19.2 job-years
- $709,000 in labor income
- $768,000 in value added
- $1,681,000 in economic output

Long Draw Fire Emergency Stabilization and Rehabilitation



BLM employees monitoring the growth progress of grass seedlings. Photo credit: Brian Watts, BLM.

Background information.—The Long Draw fire was ignited by a lightning strike on July 8, 2012, on land southwest of Burns Junction, Oregon. Within 2 hours, the fire had burned several thousand acres. By the time of containment on July 16, 2012, the fire had burned a total of 558,198 acres of land that had previously provided forage for livestock and wild horses and habitat for sage-grouse and other wildlife. As a consequence of this fire, the burned area faced the immediate risks of erosion and invasion by noxious weeds. The Bureau of Land Management's (BLM's) Vale District responded to this threat with the Long Draw Fire Emergency Stabilization and Rehabilitation Plan, which is designed to ensure recovery and protection of natural resources, promote desirable vegetation cover, and restore wildlife habitat. Treatments across the landscape included seeding of native and other perennial grasses, aerial and drill seeding of sagebrush seeds, installation of temporary and permanent fencing, repair of water infrastructure, and treatment and monitoring of identified invasive noxious weeds. The goal of this project is to restore the ecological condition and function of the landscape, which, if achieved, will result in improved habitat for wildlife, allow for continued livestock grazing through improved forage availability, provide habitat for wild horses, reduce the risk of erosion, enhance recreation opportunities, and provide better community protection from the risk of future wildfires.

The U.S. Geological Survey collected data on restoration activities and expenditures to estimate the economic activity supported by this project. Background information on the Long Draw project was obtained from Brian Watts, BLM, written commun., 2015; and Blackwood, 2013.

Economic impacts.—The Long Draw fire restoration project began in 2013 and continued into 2014, and had a total cost of more than $5,525,000 during this period (2014 dollars). Approximately 69 percent of project funds was spent within the local economy, and supported an estimated total of 46.6 job-years; $2,262,000 in labor income; $2,664,000 value added; and $6,248,000 in economic output within the local region near the fire's recovery effort. Including both local and nonlocal expenditures, the Long Draw fire restoration project supported an estimated 89.5 job-years; $5,263,000 in labor income; $6,713,000 in value added; and $13,514,000 in economic output in the Western States economy. The Long Draw fire restoration project will continue after 2014.

Long Draw Fire Emergency Stabilization and Rehabilitation Plan

Total project expenditures: $5,525,000

Western States economic impacts:
- 89.5 job-years
- $5,263,000 in labor income
- $6,713,000 in value added
- $13,514,000 in economic output

Local project expenditures: $3,800,000

Local economic impacts:
- 46.6 job-years
- $2,262,000 in labor income
- $2,664,000 in value added
- $6,248,000 in economic output

Economic Impacts of the Zuni Mountains Forest Restoration Project

Background information.—This fuels reduction project, which was conducted by the Bureau of Land Management's (BLM's) Rio Puerco Field Office, consisted of woodland habitat restoration in the Zuni Mountains approximately 45 miles south of Grants, New Mexico. Topography of the landscape includes mesas and canyons, with north-facing slopes dominated by stands of ponderosa pine with an open, grassy understory. Like other places in the American West, pinyon and juniper have encroached into open meadows and stands of ponderosa pine, which is most likely because of the lack of a natural fire regime. This change to the wooded landscape has dramatically increased hazardous fuels buildup and the associated risk of wildfire, which then increases the risk of loss to both habitat and human infrastructure. As part of the BLM's "Restore New Mexico" initiative, this project was designed to support ongoing landscape-scale woodland and watershed restoration, while promoting collaborative approaches towards forest management efforts. The BLM worked collaboratively with the New Mexico Forest Industries Association (NMFIA) during 2013 and 2014 to identify sites for treatment and project locations that would best promote the utilization of forest products removed during the project. In addition to collaboratively developing treatment specifications with NMFIA, the BLM was also involved in treating approximately 1,000 acres of pinyon and juniper woodlands to reduce fuel loads and wildfire risk, and improve forest and watershed health and resiliency. Treatments included selective and group thinning with slash treatment to reduce stand densities and promote diversity in the vegetative community, and preparation of the fuel bed after prescribed burning to help increase groundcover and reduce erosion risk. This project successfully increased grass, forbs, and shrub production throughout the project landscape.

The U.S. Geological Survey collected data on restoration activities and expenditures to estimate the economic activity supported by this project. Background information on the Zuni Mountains project was obtained from Jeremy Kruger, BLM written commun., 2015.

Juniper and pinyon stands pre- and post-thinning treatments. Photo credit: Jeremy Kruger, BLM.

Economic impacts.—The Zuni Mountains Forest Restoration Project was conducted in 2013 and 2014, with a total cost of approximately $87,000 (2014 dollars). Approximately 72 percent of project expenditures was made locally, which supported an estimated 1.5 job-years; $60,000 in labor income; $23,000 in value added; and $79,000 in economic output within the local economy. Expanding to include the effects of both local and nonlocal expenditures, the Zuni Mountains Forest Restoration Project supported an estimated 2.5 job-years; $103,000 in labor income; $121,000 in value added; and $218,000 in economic output in the Western States economy.

Zuni Mountains Forest Restoration Project

Total project expenditures: $87,000

Western States economic impacts:
- 2.5 job-years
- $103,000 in labor income
- $121,000 in value added
- $218,000 in economic output

Local project expenditures: $63,000

Local economic impacts:
- 1.5 job-years
- $60,000 in labor income
- $23,000 in value added
- $79,000 in economic output

References Cited

Barrett, S., Havlina, D., Jones, J., Hann, W., Frame, C., Hamilton, D., Schon, K., Demeo, T., Hutter, L., and Menakis, J., 2010, Interagency fire regime condition class guidebook version 3.0: National Interagency Fuels, Fire, & Vegetation Technology Transfer, accessed June 16, 2015, at http://fire.org/niftt/released/FRCC_Guidebook_2010_final.pdf.

Blackwood, J.D., 2013, Long Draw/Miller Homestead fire review—Vale and Burns Districts: Pendleton, Oregon, Vertical Grain Consulting, prepared for the Bureau of Land Management, 40 p., accessed May 13, 2015, at http://www.blm.gov/or/news/files/long-draw.pdf.

Blank, Robert; Bunting, Steve; Hild, Ann L.; Kinter, Cecilia Lynn; McArthur, Durant; Meyer, Susan; Miller, Rick; Roundy, Bruce; Whittaker, Allison; Shaw, Nancy; and Tausch, Robin, 2008, Sagebrush steppe—A story of encroachment and invasion: Joint Fire Science Program Fire Science Brief, Issue 27, accessed June 16, 2015, at https://www.firescience.gov/projects/briefs/00-1-1-03_FSBrief27.pdf.

Freshwater Mollusk Conservation Center, 2015, Mussel life history & fish hosts: Virginia Tech, Freshwater Mollusk Conservation Center, accessed May 1, 2015, at http://www.fishwild.vt.edu/mussel/research/life_history.html.

O'Quinn, J., 2014, Total maximum load (TMDL): *in* Virginia Department of Minerals and Energy Division of Mined Land Reclamation, Water Quality Section News Letter, November 2014 Issue, accessed May 7, 2015, at https://www.dmme.virginia.gov/DMLR/pdf/WaterQualityNewsLetters/2014/GinCreekNewsletter11_14.pdf.

Resource Concepts, Inc., 2005, Nevada community wildfire risk/hazard assessment project, Lincoln County: Resource Concepts, Inc., accessed May 13, 2015, at http://www.rci-nv.com/reports/lincoln/toc.html.

Stratus Consulting Inc., 2009, Final restoration plan and environmental assessment for the Tiger and Dinero Tunnels restoration: Stratus Consulting Inc., 36 p., accessed June 1, 2015, at http://www.cerc.usgs.gov/orda_docs/DocHandler.ashx?ID=151.

Stratus Consulting Inc., 2010, Restoration plan and environmental assessment for the Upper Arkansas River Watershed: Stratus Consulting Inc., 111 p., accessed June 1, 2015, at http://www.cerc.usgs.gov/orda_docs/DocHandler.ashx?ID=152.

U.S. Department of Agriculture, Natural Resource Conservation Service, 2008, Final plan and environmental assessment, North Fork Powell River Watershed: U.S. Department of Agriculture, 193 p., accessed May 13, 2015 at https://www.dmme.virginia.gov/DMLR/pdf/North%20Fork%20Powell%20combined%20document%204_09.pdf.

U.S. Department of the Interior, Bureau of Land Management, [2012], Jarbidge Field Office programmatic shrub planting—Environmental assessment ID-210-2008-EA-359: Bureau of Land Management, 42 p., accessed August 25, 2015, at https://eplanning.blm.gov/epl-front-office/projects/nepa/34553/41233/43503/2012_02_01_JFO_Shrub_EA_Final_508.pdf.

U.S. Department of the Interior, Bureau of Land Management, 2015, Burley landscape sage-grouse habitat restoration partnerships: Bureau of Land Management, accessed August 25, 2015, at http://www.blm.gov/id/st/en/prog/wildlife_and_fisheries/habitat_improvement/bur_burley_landscape.html.

U.S. Environmental Protection Agency, 2014, Record of Decision amendment 2 (interim remedy) PCB Areas Operable Unit Sangamo Electric Dump/Crab Orchard National Wildlife Refuge Superfund site: U.S. Environmental Protection Agency Region V, Chicago, Illinois, accessed February 9, 2016, at https://semspub.epa.gov/work/05/472685.pdf.

U.S. Fish and Wildlife Service, 2003, Final restoration plan and environmental assessment for the Lone Mountain Processing Inc. Coal Slurry Spill Natural Resource Damage Assessment: U.S. Fish and Wildlife Service, 48 p., accessed May1, 2015, at http://www.cerc.usgs.gov/orda_docs/DocHandler.ashx?ID=517.

U.S. Fish and Wildlife Service, 2013, Greater sage-grouse (*Centrocercus urophasianus*) conservation objectives—Final report: Denver, Colorado, U.S. Fish and Wildlife Service.

Appendix 2. The Project Summary Survey

Thank you for agreeing to include your restoration project in our study of the economic contributions of restoration. Your responses to this survey will give us the background information that we need to get started with our analysis. Following this survey, we will send you and the contractors that you identify an expenditure survey. The expenditure survey will ask each participant about their expenditures on labor, equipment, repairs and maintenance, materials and supplies, overhead, and travel for this restoration project. We will use this information to estimate the employment impacts of this restoration project.

This initial project summary survey will take approximately 15-30 minutes to complete. You can pause at any time; simply close the window and your answers will be saved. To resume and complete the survey, you will need to click on the link to the survey in the email you received. At that point, you can answer any remaining questions and/or edit any of your previous responses. At the end of the survey, click on the "Submit" button to finish the survey.

Thank you,

This survey was approved by the Office of Management and Budget (1028-0107).

1. **Name of restoration project: ________________________________**

2. **If applicable, name of NRDA case and state. If project is funded by more than one case settlement, please list additional case names (please use the official Restoration Program case name available at http://www.doi.gov/restoration/library/casedocs/index.cfm):**

   ____

3. **Indicate the cause of the injury to land that required restoration actions:** *(Check all that apply)*

   _____Oil (OPA)
   _____Hazardous substances (CERCLA)/hazardous materials (RCRA)
   _____Fire
   _____Human-built, temporary or permanent structures (such as roads, dams, buildings, pipelines)
   _____Natural processes/hazards (e.g., flooding, landslide, mudslide, earthquake, hurricane)
   _____Mining
   _____Other (*please describe*)

4. **Please identify the location of the restoration actions** *(Check all that apply)*:

   _____U.S. Department of the Interior land (e.g., National Park Service, Bureau of Land Management, Fish and Wildlife Service)
   _____Other U.S. Government land
   _____State land
   _____Local land (e.g., county or city)
   _____Tribal land
   _____Private land
   _____Land outside the U.S.

5. **Please indicate how the restoration actions were accomplished**: *(Check all that apply)*

   _____Realty actions (i.e., purchased or acquired easements or otherwise acquired land for U.S. Department of the Interior Land or other U.S. Government land, private land, or land outside the U.S.)
   _____Enhancement of existing (improve baseline conditions)
   _____Creation/conversion of existing (change baseline conditions)

6. **As part of the restoration project, indicate any realty actions (i.e., purchased or acquired easements or otherwise acquired land for U.S. Department of the Interior Land or other U.S. Government land, private land, or land outside the U.S.*)*:** *(Check all that apply)*

   _____Conservation easement
   _____Land acquisition
   _____Direct land swap
   _____Transfer to third party for conservation
   _____Other (*please describe*)

7. **Please identify the restoration site land cover:** *(check one)*

_____Primarily terrestrial
_____Primarily aquatic
_____Both aquatic and terrestrial

8. **Please indicate the land cover type or condition using the following terrestrial categories**: *(Check all that apply)*

_____Mostly broadleaf
_____Mostly conifer
_____Mostly shrub/scrub
_____Mostly herbaceous (grass, sedge, forb)
_____Barren/rock
_____Arid/desert
_____Waste/impaired for organismal life
_____Built (human-based structures and roads)
_____Other (*please describe*)

9. **Please indicate the land cover type or condition using the following aquatic categories**: *(select all that apply)*

_____Riverine (non-tidal)
_____Lacustrine (lake environment)
_____Marine
_____Tidally influenced/coastal/beach
_____Wetland
_____Spring/fen (groundwater influenced)
_____Other (*please describe*)

10. **Please indicate the type of riverine system using these sub-categories:**

_____Perennial stream/river
_____Intermittent stream/creek
_____Headwater channel
_____Other (*please describe*)

11. **Please select the restoration focus that applies to this specific action. Please note that restoration intended to benefit specific organisms primarily through habitat work should be considered habitat-based**: *(Check all that apply)*

_____Habitat-based
_____Organism-based
_____Non-biotic human use and (or) cultural (non-Tribal)
_____Tribal

12. Please indicate the habitat-based restoration actions using the following categories: *(Check all that apply)*

_____Planting
_____Seeding
_____Propagating
_____Storage (e.g., seed banking)
_____Invasive species control
_____Cropland conversion
_____Woody fuels management
_____Herbaceous fuels management
_____Vegetation management
_____Debris addition (e.g., coarse woody)
_____Bank stabilization/erosion control
_____Contouring
_____Dam removal
_____Channelization
_____De-channelization
_____Culvert replacement
_____Erosion control
_____Sediment removal
_____Coral reef restoration
_____Wetland creation
_____Marsh creation
_____Shoreline restoration
_____Other

13. Please indicate which of the following were included in the organism-based restoration actions: *(Check all that apply)*

_____Bird
_____Fish
_____Mammal
_____Amphibian
_____Reptile
_____Mollusk
_____Invertebrate (not including mollusk)
_____Grass
_____Forb
_____Shrub
_____Tree
_____Other (e.g., lichen, moss, etc.) (*please describe*)

14. Please indicate the listing status of the organism on which the restoration actions were focused: *(Check all that apply)*

_____Federally threatened or endangered species
_____State threatened or endangered species
_____Non-listed species
_____Other special concerns (*please describe*)

15. Please indicate the faunal organism-based restoration actions: *(Check all that apply)*

_____Protection
_____Breeding/Hatching/Rearing
_____Nest creation/inserts
_____Reintroduction/translocation
_____Other (*please describe*)

16. Please indicate the floral organism-based restoration actions: *(Check all that apply)*

_____Protection
_____Plant propagation
_____Seeding
_____Planting
_____Storage (e.g., seed banking)
_____Other (*please describe*)

17. Please indicate the non-biotic human use restoration actions of this project: *(Check all that apply)*

_____Built/replaced/repaired (e.g., buildings, boat ramps, trails)
_____Education (e.g., signage, visitor center, audio/visual materials, social media, classes)
_____Removal (e.g., dam, building, road)
_____Other (*please describe*)

18. If applicable, please indicate the non-biotic human use restoration actions that were conducted for cultural, non-tribal purposes and provide a brief description of this purpose (e.g., archaeological, historical significance): *(Check all that apply, plus open-ended response for each checked action)*

_____Built/replaced/repaired (e.g., buildings, boat ramps, trails)
_____Education (e.g., signage, visitor center, audio/visual materials, social media, classes)
_____Removal (e.g., dam, building, road)
_____Other (*please describe*)

19. Please indicate the tribal restoration actions of this project: *(Check all that apply)*

_____ Cultural/religious/spiritual
_____ Ecological
_____Educational (e.g., job training, scholarships, signage, interpretation)
_____Economic (e.g., commercial fishery, tourism)
_____Other (*please describe*)

20. What was the total project expenditure? $______________

21. Did you hire any contractors to work on this restoration project? (*Contractors are firms hired to perform and conduct components of this restoration project*)

_____Yes

_____No

22. How many different contractors were hired to work on this restoration project? *(Can be any whole number)*____

23. How much was spent in-house and on contracting? *(Contracting expenditures include the total amount to hire firms to perform and conduct components of this restoration project.*)

	Total Expenditures ($)
In-House	
Contractor 1	
Contractor 2	
Contractor 3	
Contractor 4	
Contractor 5	

24. Non-monetary exchanges: Were any non-monetary exchanges included in the project? An example of a non-monetary exchange would be paying a contractor with timber removed from the restoration site as part of the larger restoration project.

_____Yes

_____No

25. Please provide any additional information on the exchange and how the products of the exchange may be used (e.g., biomass for energy production, timber likely destined for a pulp mill, or furniture production). Please be as specific as possible.

26. Please describe the restoration action(s) that were <u>performed in-house</u>. For each action, please indicate the type of action. For example, if you did archeological work in-house as part of your planning and part of your monitoring, you would write archeology as Action 1 and check both the planning and monitoring boxes for that action.

	Type of Action		
	Planning	**Implementation**	**Monitoring**
Action 1:____________________	☐	☐	☐
Action 2:____________________	☐	☐	☐
Action 3:____________________	☐	☐	☐
Action 4:____________________	☐	☐	☐
Action 5:____________________	☐	☐	☐

27. Please provide contact information, payment amount, and starting and ending dates for each contractor hired for this restoration project.

Name of firm: ____

Point of contact: ____

Phone number: ____

Email address: ____

28. Please describe the restoration action(s) that this contractor was hired to do. For each action, please indicate the type of action. For example, if the contractor was hired to do archeological work as part of your planning and part of your monitoring, you would write archeology as Action 1 and check both the planning and monitoring boxes for that action.

	Type of Action		
	Planning	**Implementation**	**Monitoring**
Action 1: ____________________	☐	☐	☐
Action 2: ____________________	☐	☐	☐
Action 3: ____________________	☐	☐	☐
Action 4: ____________________	☐	☐	☐
Action 5: ____________________	☐	☐	☐

Thank you for taking the time to provide this information about your restoration project. In order to prevent duplication of data, can you please tell us if you have been asked similar questions about this restoration project by another federal agency. If yes, please identify the Federal agency.

Appendix 3. The Expenditure Survey

Thank you for participating in our study of the economic contributions of restoration. This survey will ask you about your firm's expenditures on labor, equipment, repairs and maintenance, materials and supplies, overhead, and travel for this restoration project. We will use this information to estimate the employment impacts of this restoration project.

This survey will take approximately 30 minutes to complete. You can pause at any time; simply close the window and your answers will be saved. To resume and complete the survey, you will need to click on the link to the survey in the email you received. At that point, you can answer any remaining questions and/or edit any of your previous responses. At the end of the survey, click on the "Submit" button to finish the survey.

Thank you,

This survey was approved by the Office of Management and Budget (1028-0107).

1. **The project manager indicated that your firm worked on the following activities:** ***(list shown here)***

   Of the $X paid to your firm for this project, please indicate that percent applied to the work performed each restoration activity:

   Note:
   Labor costs: includes the full costs of labor including benefits, wages, taxes and insurance to employees of your firm and any contracted labor. This amount should also include proprietor's income.
   Non-labor costs: includes all other non-subcontracting expenses including overhead and administration.
   Contracting ***(or subcontracting)*** **costs:** includes the total amount to hire other firms to perform and conduct components of this restoration project.

Restoration activity	Percent of total cost	Starting date of activity	Ending date of activity

2. **This section splits expenditures by restoration activity. You will be asked to complete the expenditure splits for each restoration activity that your firm worked on.**

   <u>Note</u>:
   Labor costs: includes the full costs of labor including benefits, wages, taxes and insurance to employees of your firm and any contracted labor. This amount should also include proprietor's income.
   Non-labor costs: includes all other non-subcontracting expenses including overhead and administration.
   Contracting *(or subcontracting)* costs: includes the total amount to hire other firms to perform and conduct components of this restoration project.

Expenditure Category	**% of total cost by activity**
Labor Cost	
Non-Labor Cost	
Contracting Cost	

3. **Please break your non-labor expenses for this restoration project into the following categories.**

   <u>Note:</u>
   Equipment: refers to durable goods such as vehicles and machinery.
   Materials: refer to goods purchased as inputs specifically for this project (e.g. gravel, fencing, office supplies, etc.)

Non-Labor Cost Categories	**Non-labor expenditures ($):**	**% spent within the local area**
Equipment rental/leasing/daily use rates		
Equipment maintenance and repair		
Materials		
Travel		
Overhead/Administration		
Other (please describe)		

4. **Please break your firm's travel expenses for this restoration project into the following categories.**

Travel Cost Categories	**Travel Expenditures ($)**	**% spent within the local area**
Per diem (including lodging, food, and incidental expenses)		
Car/truck rental (for travel)		
Gas (for travel)		
Other (including airfare)		

5. **Please break the materials expenses for this restoration project into the following categories. Your responses should add to the total materials costs of $X.**

Materials	**Materials Expenditures ($)**	**% spent within the local area**	**Type of business was material was purchased from:**
General retail merchandise (e.g., food, clothes, work gloves)			
Office Supplies			
Gasoline			
Fencing (wood)			
Fencing (wire)			
Wood products (e.g., chips, posts, ties)			
Metal posts			
Plastic netting (e.g., Tensar)			
Natural Fiber fabrics			
Synthetic fabrics			
Water and water delivery systems			
Soil			
Seeds			
Nursery/greenhouse products			
Sand and gravel			
Rocks and riprap			
Mulch (hay, straw, etc.)			
Soil amendments (lime, organic wastes, binders, etc.)			

Fertilizers, pesticides and other agricultural chemicals			
Plastic pipes and pipe fittings (excluding water delivery systems)			
Concrete pipes and conduits			
Brick/concrete products (not including pipes)			
Ready-Mix Concrete			
Hardware (e.g. bolts, nuts, screws, spikes)			
Paint and other coatings			
Communications equipment			
Other (please describe)			

6. **Please break your firm's labor expenses for this restoration project into the following categories. Labor expenses include the full costs of labor including benefits, wages, taxes and insurance to employees of your firm and any contracted labor. Labor expenses also include proprietor's income.**

Type of Worker	**Labor Expenditures ($)**	**% who live and work within the local area**	**Average payroll cost ($/hour)**
Non-seasonal labor			
Seasonal labor			

7. **Please break your firm's labor expenses for this restoration project into the following categories. Labor expenses include the full costs of labor including benefits, wages, taxes and insurance to employees of your firm and any contracted labor. Labor expenses also include proprietor's income.**

Seasonal labor	
Number of seasonal laborers hired:	
Average length of employment (weeks):	

8. **For each subcontractor, indicate if the subcontractor is located in the local area surrounding the project location. Choose a category that best represents the type of work performed by the subcontractor.**

Subcontractor	% of subcontracting expenditures	Is the subcontractor located within the local area?	Subcontractor category (please choose # from list below)
Subcontractor 1			
Subcontractor 2			
Subcontractor 3			
Subcontractor 4			

Subcontractor was primarily engaged in:
1. one or more of the following: (A) cutting timber; (B) cutting and transporting timber; and (C) producing wood chips in the field
2. performing particular support activities related to timber production, wood technology, forestry economics and marketing, and forest protection. These establishments may provide support activities for forestry, such as estimating timber, forest firefighting, forest pest control, and consulting on wood attributes and reforestation.
3. providing support activities for growing crops. Activities include aerial dusting or spraying, farm management services, planting crops, cultivation services, and vineyard cultivation services
4. providing support activities for growing non-crop horticultural products. Activities include weed spraying, and planting.
5. construction of new structures.
6. maintenance and repair of existing structures.
7. providing advice and assistance to businesses and other organizations on management issues, such as strategic and organizational planning; financial planning and budgeting; marketing objectives and policies; human resource policies, practices, and planning; production scheduling; and control planning.
8. providing advice and assistance to businesses and other organizations on environmental issues, such as the control of environmental contamination from pollutants, toxic substances, and hazardous materials.
9. providing a range of day-to-day office administrative services, such as financial planning; billing and recordkeeping; personnel; and physical distribution and logistics.

10. providing landscape care and maintenance services and/or installing trees, shrubs, plants, lawns, or gardens
11. planning and designing the development of land areas for projects, such as parks and other recreational areas
12. performing surveying and mapping services of the surface of the earth, including the sea floor.
13. the collection, treatment, and disposal of waste materials including remediation services.

Appendix 4. IMPLAN Sector Crosswalk for Restoration Activities

Restoration activity	Best-fit sector[1]	Sector description
Project management activities		
Project management Planning, coordination, and oversight (Federal government)	Imported institutional spending pattern	Federal government non-defense
Project management Planning, coordination, and oversight (State or local government)	Imported institutional spending pattern	State/local government non-education
Project management Planning, coordination, and oversight (conservation and environmental organizations)	424	Grant making, giving, and social advocacy organizations
Planning, coordination, and oversight (private consulting firms)	375	Environmental and other technical consulting services
Design activities		
Design work (such as landscape, remediation, and hydrology design)	369	Architectural, engineering, and related services
Planting and seeding activities		
Plant/tree nursery production	6	Greenhouse, nursery, and floriculture production
Seed production	10	All other crop farming
Native/wild seed collection	19	Support activities for agriculture and forestry
Planting	19	Support activities for agriculture and forestry
Seeding	19	Support activities for agriculture and forestry
Aerial seeding	332	Transport by air
Landscape treatment activities		
Noxious and invasive weed inventory, treatment, and monitoring	19	Support activities for agriculture and forestry
Hand thinning (trees and shrubs)	19	Support activities for agriculture and forestry
Mechanical thinning (trees and shrubs)	16	Commercial logging
Mechanical mulching (trees and shrubs)	16	Commercial logging
Mechanical mastication (trees and shrubs)	16	Commercial logging
Terrestrial and stream construction activities		
Streambank stabilization	30	Support activities for other mining
Wetland construction	30	Support activities for other mining

Restoration activity	Best-fit sector[1]	Sector description
Other construction activities		
Acid mine drainage construction	30	Support activities for other mining
Drilling	28	Drilling oil and gas wells
Fence construction	19	Support activities for agriculture and forestry
Path construction	36	Construction of other new nonresidential structures
Sign construction	314	Sign manufacturing
Remediation and hazardous waste activities		
Hazardous waste/structure removal	390	Waste management and remediation services
Remediation	390	Waste management and remediation services
Monitoring, inspection, and other professional service activities		
Archaeology and cultural surveys	375	Environmental and other technical consulting services
Land surveys	369	Architectural, engineering, and related services
Inspection (environmental)	375	Environmental and other technical consulting services
Inspection (construction)	369	Architectural, engineering, and related services
Water quality monitoring	375	Environmental and other technical consulting services
Electrical work	31	Electric power generation, transmission, and distribution
Realty and legal services	367	Legal services

[1]Sectors are from the IMPLAN 440 sector scheme, which is applicable to IMPLAN data years 2007–2012. A 440 to 536 bridge is available from IMPLAN for use with data years 2013 and later.

Appendix 5. IMPLAN Sector Crosswalk for Restoration Expenditure Categories

Expenditure category	IMPLAN activity type	Sector[1]	Sector description
Employee compensation	Labor income change	5001	Employee compensation
Proprietor income	Labor income change	6001	Proprietor income
Equipment rental/leasing /daily use rates	Industry change	365	Commercial and industrial machinery and equipment
Equipment maintenance and repair	Industry change	417	Commercial and industrial machinery and repair, and maintenance services
Overhead/administration	Industry change	384	Management of companies and enterprises
Per diem	Commodity change(M)		
Dining (60 percent)		411	Hotel and motel service, including casino hotels
Hotels (40 percent)		413	Restaurant, bar, and drinking- place services
Car/truck rental	Industry change	362	Automotive equipment rental and leasing
Gas	Commodity change(M)	115	Petroleum refineries
General retail merchandise	Commodity change(M)	330	Retail stores—Miscellaneous
Office supplies	Commodity change(M)	330	Retail stores—Miscellaneous
Gasoline	Retail/wholesale: Commodity change(M) Direct from manufacturer: Industry change	115	Petroleum refineries
Fencing (wood)	Retail/wholesale: Commodity change(M) Direct from manufacturer: Industry change	103	All other miscellaneous wood product manufacturing
Fencing (wire)	Retail/wholesale: Commodity change(M) Direct from manufacturer: Industry change	194	Spring and wire product manufacturing
Wood products (such as chips, posts, ties)	Retail/wholesale: Commodity change(M) Direct from manufacturer: Industry change	103	All other miscellaneous wood products
Metal posts	Retail/wholesale: Commodity change(M) Direct from manufacturer: Industry change	170	Iron and steel and ferroalloy products
Plastic netting (such as Tensar)	Retail/wholesale: Commodity change(M) Direct from manufacturer: Industry change	149	Other plastics product manufacturing
Natural fiber fabrics	Retail/wholesale: Commodity change(M) Direct from manufacturer: Industry change	76	Broadwoven fabric mills

Expenditure category	IMPLAN activity type	Sector[1]	Sector description
Synthetic fabrics	Retail/wholesale: Commodity change (M) Direct from manufacturer: Industry change	78	Nonwoven fabric mills
Water and water delivery systems	Direct from manufacturer: Industry change	33	Water, sewage, and other treatment and delivery systems
Soil	Retail/wholesale: Commodity change (M) Direct from manufacturer: Industry change	130	Fertilizer
Seeds	Retail/wholesale: Commodity change (M) Direct from manufacturer: Industry change	10	All other crop farming products
Nursery/greenhouse products	Retail/wholesale: Commodity change (M) Direct from manufacturer: Industry change	6	Greenhouse, nursery, and floriculture products
Sand and gravel	Retail/wholesale: Commodity change (M) Direct from manufacturer: Industry change	26	Sand, gravel, clay, and refractory minerals
Rocks and riprap	Retail/wholesale: Commodity change (M) Direct from manufacturer: Industry change	25	Stone
Mulch (such as hay, straw)	Retail/wholesale: Commodity change (M) Direct from manufacturer: Industry change	10	All other crop farming products
Soil amendments (such as lime, organic wastes, binders)	Retail/wholesale: Commodity change (M) Direct from manufacturer: Industry change	130	Fertilizer
Fertilizers, pesticides and other agricultural chemicals	Retail/wholesale: Commodity change (M) Direct from manufacturer: Industry change	131	Pesticides and other agricultural chemicals
Plastic pipes and pipe fittings (excluding water delivery systems)	Retail/wholesale: Commodity change (M) Direct from manufacturer: Industry change	144	Plastic pipe and pipe fittings
Concrete pipes and conduits	Retail/wholesale: Commodity change (M) Direct from manufacturer: Industry change	162	Concrete pipes, bricks, and blocks
Brick/concrete products (not including pipes)	Retail/wholesale: Commodity change (M) Direct from manufacturer: Industry change	162	Concrete pipes, bricks, and blocks
Ready-mix concrete	Retail/wholesale: Commodity change (M) Direct from manufacturer: Industry change	161	Ready-mix concrete
Hardware (such as bolts, nuts, screws, spikes)	Retail/wholesale: Commodity change (M) Direct from manufacturer: Industry change	193	Hardware

Expenditure category	IMPLAN activity type	Sector[1]	Sector description
Paint and other coatings	Retail/wholesale: Commodity change [(M)] Direct from manufacturer: Industry change	136	Paints and coatings
Communication equipment	Retail/wholesale: Commodity change [(M)] Direct from manufacturer: Industry change	238	Broadcast and wireless communications equipment

[(M)]Margined using industry margins. For wholesale purchases, retail margins are set to 0 percent and margins are rebalanced.

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