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REVIEW ARTICLE

Defining and evaluating the ecological restoration economy

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For decades, industry groups and many media outlets have propagated the notion that environmental protection is bad for business. However, missing from this public debate has been a detailed accounting of the U.S. economic output and employment that are created through conservation, restoration, and mitigation actions, which we call the "Restoration Economy." In this paper, we review related literature, including 14 local and state-level case studies of privately funded environmental restoration projects. We also review federal and state government programs that fund restoration throughout the United States, revealing the complex nature of this sector. We find growing evidence that the restoration industry not only protects public environmental goods but also contributes to national economic growth and employment, supporting as many as 33 jobs per $1 million invested, with an employment multiplier of between 1.48 and 3.8 (the number of jobs supported by every restoration job) and an output multiplier of between 1.6 and 2.59 (multiplier for total economic output from investments). The existing literature also shows that restoration investments lead to significant positive economic and employment impacts and appear to have particularly localized benefits, which can be attributed to the tendency for projects to employ local labor and materials. While these initial figures are promising, the extent of environmental restoration activities and benefits at a national level is not yet well understood. Our findings reveal the need for a methodological framework for more accurately and broadly estimating the size of the U.S. restoration sector and its impact on the U.S. economy.

Key words: ecological restoration, economic impacts, environmental planning, restoration industry

CONCEPTUAL IMPLICATIONS

- The ecological restoration process—planning, site construction, monitoring, etc.—generates economic output and employment, which forms the "ecological restoration economy."
- Economic impact assessments—which are typically done at the county and state scales—suggest that ecological restoration resembles other industries (e.g. crop agriculture and outdoor recreation) in terms of employment and economic output multipliers.
- Budget information on U.S. state and federal programs that fund ecological restoration is inconsistent, incomplete, and is in need of stringent tracking.
- There is a remaining need for assessments that perform complete welfare or cost–benefit analyses, which weigh the opportunity costs of restoration (lost economic output) with the economic, social, and environmental benefits of restoration.

Introduction

For decades, business groups and various media outlets have crafted a powerful narrative that environmental protection is bad for business (Goodstein 1994; Bezdek et al. 2008). Recent polls demonstrate that this idea is widely accepted as fact by the public (Chinni 2011) and those responsible for projects that require environmental permits in order to impact species habitat, water resources, and other natural features often argue that more such regulations kill jobs ("Green Tape"). Emblematic of this trend, the U.S. Chamber of Commerce recently released a report, *Progress Denied*, arguing that "corrosive" declines in job growth were the result of environmental permitting processes (Pociask & Fuhr 2011).

However, missing from this public debate has been a detailed accounting of the economic output and jobs in the United States that are actually created through environmental conservation, restoration, and mitigation actions—the activities that are part of the "Restoration Economy." These activities are undertaken by a variety of existing industries, including earth movers, plant nurseries, legal and planning practices, landscape architects, and construction, as well as a number of newly emerging industries,

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including mitigation banking, and other activities that contribute to the ecological restoration process.

Restoration is inextricably embedded within an economic framework; the necessity of restoration is usually a product of past economic activity, while the demand for restoration, and the resources that are provided to carry it out, is controlled by current economic circumstances (Edwards & Abivardi 1997). For restoration efforts to succeed on a large scale, it is essential that insights from ecology and economics be brought together (Holl & Howarth 2000; Blignaut et al. 2014; see Supp. Information 1 in Appendix S1 for more on recent discussions on the "Green Economy"). However, a recent survey of over 1,000 peer-reviewed restoration papers found that restoration practitioners are failing to draw links between ecological and socioeconomic benefits, underselling the evidence of benefits of restoration as a worthwhile investment for society (Aronson et al. 2010).

In this article, our goal is to synthesize previous work in this area (including numerous regional case studies), while outlining both the drivers of demand for restoration and the magnitude of aggregate restoration funding in the United States. To do this, we first aim to create an inclusive and clear definition of *ecological restoration*, defining the *restoration industry* based on the factors that drive demand for restoration. This detailed discussion can be found in Supp. Information 2 in Appendix S1. Second, we provide a comprehensive review of federal and state government programs that fund restoration throughout the United States, an effort that reveals the complexity of this sector. While our focus is primarily on funding apparatuses, we do note the complex and patchwork of federal, state, and local tax preferences for undertaking conservation and restoration activities. Finally, we review previous work to quantify the economic contributions of privately and publicly funded restoration. We distinguish economic and ecosystem benefits—the services produced by increased ecological quality—from economic output and employment impacts of restoration.

Similar to the way that the monetized costs of environmental regulatory placed on the economy are calculated and articulated, we are interested in the aggregate size of the restoration economy. Our findings suggest the need for a more formalized framework that accurately and broadly estimates the size of the U.S. restoration sector and its impact on the U.S. economy in terms of total economic output and employment.

Originating Demand for Restoration

A major challenge to quantifying the economic and employment impacts of the restoration industry is that it is spread across a diverse set of actors. As we will demonstrate, restoration is largely driven by legal requirements and public sector investment arrangements, which can be quite complex. Many restoration projects result from interagency collaborations and public–private partnerships, so that tracking investments requires cross-referencing contracts and budgets from multiple sources (Nielsen-Pincus & Moseley 2010; see more information in Supp. Information 3 in Appendix S1, under public procurement). In this section, we will describe demand for restoration within this context. First, we will describe our methods and present our assessment of public sector expenditures (federal and state). Using this assessment, we will outline five separate origins of demand for domestic ecological restoration.

Methods for Estimating Restoration Demand

To measure the extent of restoration activity—and ultimately in order to ascertain the major policy drivers for restoration work—we performed a detailed review of public sector expenditures at the state and federal levels that finance a significant portion of U.S. restoration activity and cataloged the various public and private sources of restoration demand. As existing databases are insufficient, we created a new database to track restoration investments from their point of origin (regulation, appropriation, etc.) to the on-the-ground implementation.

A systematic online search was conducted for restoration programs within each federal agency and each state agency that works on natural resource, water, fish and game, and infrastructure issues (see Supp. Information 4 in Appendix S1 for detailed methods and issues with current databases). Federal and state restoration programs were analyzed separately, and we report the results as separate values that are not directly comparable. Public investments at the state level were estimated from state agency budgets and annual reports. Information on the duration of the program or project was collected whenever possible.

The frequency of each demand driver was tallied at the program level. Summary statistics were calculated for the program appropriations for 2011, 2012, and 2013 when the most data were available. Although not directly comparable to one another, the average appropriation levels and average annual budget statistics can begin to suggest the economic scale of federal restoration initiatives.

Summarizing Public Restoration Programs

Federal Programs. Our database contained 25 federal statutes that drive some form of ecological restoration (see Supp. Information 5 in Appendix S1). These statutes guided 134 restoration programs, which led to at least 1,118 restoration projects since 2000. Of the 134 programs, the majority (54%) involved public procurement of restoration services. There were also 41 regional initiatives, 18 regulatory-induced programs, and 3 internal agency policies. Budget information was available only for 72 programs, or 54% of the total, which likely reflects the lack of emphasis placed on providing cost information on restoration projects (Bernhardt et al. 2005). The average annual budget among the 45 programs with budget information that were ongoing in 2012 was \$44.4 million with a standard deviation (SD) of \$224 million (while we present SD in accordance with typical practice and to demonstrate extent of variation, note that the data are not normally distributed). The large variance is due to the diversity of the projects themselves, which ranged from \$94,457 to \$1.5 billion per year in restoration budgeted spending. Over 67% of the programs with budget information were public procurement programs, which were also the most frequent type of restoration program in our sample.

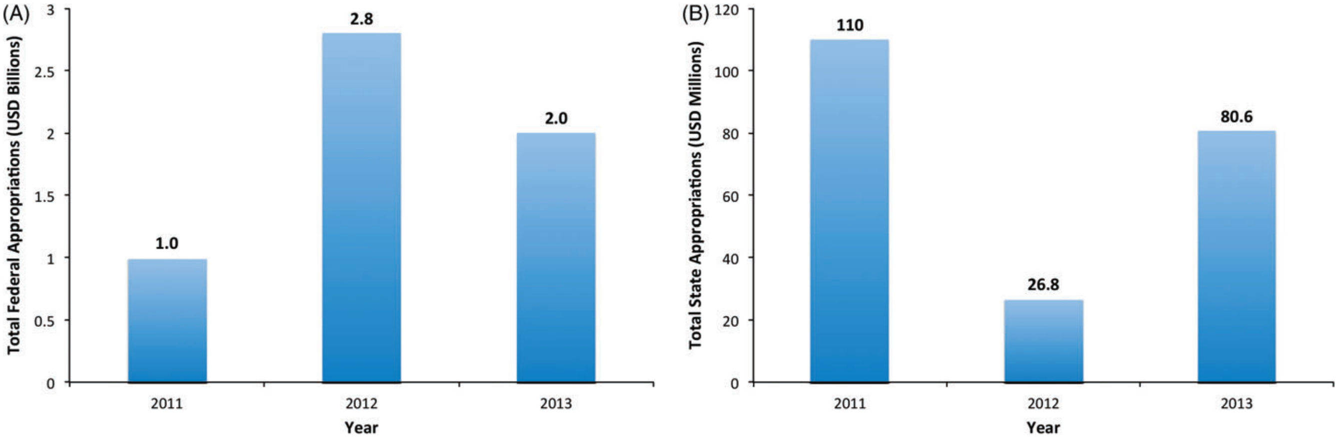

Figure 1. Total (A) federal and (B) state restoration-related appropriations, 2011–2013.

The appropriations data are also sparse, and thus highly variable. In 2011, of the six programs with special appropriations, the mean appropriation level was \$167 million (SD = \$139 million). The total amount (the accumulated cost/expenditures associated with these programs) of all restoration-related appropriations in 2011 was \$1 billion (Fig. 1). In 2012, there were 17 programs with special appropriations; the mean level was \$165 million (SD = \$293 million). The total amount of all restoration-related appropriations was \$2.8 billion. In 2013, only eight restoration programs received appropriations, which had a total value of \$2 billion. The mean appropriation level was \$252 million (SD = \$397 million).

State Programs. We identified 17 states with statutes that drive some form of ecological restoration. However, state restoration programs are also driven by federal statutes, regional initiatives, and state agency policies, so all 50 states had state-level restoration-related programs. We identified 502 state restoration programs, which have led to at least 704 restoration projects since 2000. The vast majority (90%) of state-level programs involved public procurement of restoration services, though in many cases these programs are cost-share programs with private landowners or organizations. There were also 16 regional initiatives, 24 regulatory-induced programs, and 12 internal agency policies.

Annualized budget information was available only for 93 programs, or 18% of the total, a much lower rate of data availability than reflected at the federal level. The average annual budget among the 88 programs with budget information that were ongoing in 2012 was \$17.7 million with an SD of \$105 million. As with annual program funding at the federal level, the large variance is due to the diversity of the projects, which ranged from a mere \$5,955 to over \$980 million invested in 2012.

State appropriations were not always available online, and like federal appropriations, did not always correspond to a specific program. Thus, only 13 restoration-related appropriations values were identified for 2011 at the state level, 11 for 2012, and 16 for 2013. In 2011, the mean appropriation level was \$7.9 million (SD = \$7.6 million). The total value of all restoration-related appropriations in 2011 was \$110 million (Fig. 1B). In 2012, the mean level was \$2.4 million (SD = \$3.1 million). The total value of all restoration-related appropriations was \$26.8 million. State appropriations in 2013 had a total value of \$80.6 million. The mean appropriation level was \$5.0 million (SD = \$9.8 million).

Appropriations estimates are highly conservative, given that only appropriations for specific programs were included, when available. Appropriations to state agencies that conduct restoration-related work were not counted, as we were unable to distinguish the amount of funds designated specifically for restoration programs or projects. In addition, through the database population process it became apparent that state agencies update their websites at different frequencies such that some states had no data available for programs or projects occurring after 2010, while other states only had the most recent program and project information available and lacked information about earlier programs. This finding is in line with substantial previous work across the literature and public record, which has concluded that restoration project cost and expenditure data are sorely lacking and increasingly necessary for accurate accounting (Edwards & Abivardi 1997; Holl & Howarth 2000; Brooks & Lake 2007; Robbins & Daniels 2012). Thus, while our customized restoration programs database was better suited for this analysis than existing databases, we recognize there may be bias toward programs with a stronger online presence and do not make comparisons between state funding levels.

Explaining Drivers of Restoration Demand

In analyzing these programs more closely, we can first divide the origins of restoration demand into two pieces, private and public. In the private sector, restoration occurs when private investors choose to invest in restoration programs that have the potential to produce profitable outcomes, or when private foundations, corporations, and individuals voluntarily choose to fund restoration projects. Conversely, the different investment and establishment phases of publicly funded restoration work can be organized into three categories: origination, enablement, and implementation (which itself can be broken into numerous phases; e.g. BenDor et al. (2011) delineate nine phases of restoration implementation).

The originating phase involves developing a restoration program. In the public sector, this often occurs through legislation and budget appropriations. The enabling phase is the process by which agencies or organizations research alternatives, prioritize work, and allocate funding to specific projects. Finally, implementation is the phase in which on-the-ground work is carried out to complete the project. The size of the restoration economy can then be roughly delineated by (1) identifying the major public programs that originate demand for restoration and (2) determining the manner by which demand is organized.

We can segment the drivers that create and originate demand for restoration into public and private sector drivers. Of the public sector drivers, we can consider four different factors. The first consists of regulatory drivers that mandate or incentivize public and private investments in restoration to offset development activities. Second, public procurement of restoration often occurs through programs that contract directly with restoration providers. Many federal and state agencies also provide direct and ongoing payments or grants to support ecological restoration, including the U.S. Department of Agriculture (USDA), the Department of the Interior, and the National Oceanic and Atmospheric Association (NOAA). Third, regional initiatives that include restoration are enabled through a synthesis of legislation and partnerships at different levels of government. Regional initiatives are distinguished from other demand factors by special legislation that enables agency partnerships focused on a single geographic area. Finally, internal agency policies can enable restoration when they require or allow for regular agency activities to be carried out in a more sustainable or restorative manner. We discuss these public sector factors in greater detail in Supp. Information 3 in Appendix S1.

Finally, we include private investments as the fifth driver of restoration investment; these include investments by foundations, non-profits, corporations, and institutions as a way to increase sustainability or meet corporate social responsibility goals. This fifth factor also includes philanthropic, non-profit, corporate, and institutional investments, which also generate demand for restoration activities. Private investments often occur for either profit (i.e. an investment mechanism) or cost-saving purposes (e.g. streamlined operations due to increased environmental quality). A 2013 study conducted for the National Fish and Wildlife Foundation (NFWF) found that private investments in conservation and restoration-related activities amounted to over $4.3 billion in 2012 (Southwick Associates, Inc. 2013). The study tabulated tax return data for non-profit organizations receiving exemptions for listing as *Natural Resources Conservation and Protection* and *Wildlife Preservation and Protection* entities. Although the estimate includes expenditures for both conservation and restoration activities, it provides a preliminary estimate of the total value of private, charitable restoration investments.

Many of these charitable contributions are mission-driven. The River Network, an association of nearly 2,000 different non-profit and grassroots organizations, awarded more than $150,000 in grants for restoration projects in 2011 (River Network 2011). Of the Network income in 2011, 23% came from corporate donors, 37% from foundation grants, 10% from individual donations, and only 9% from public sources (River Network 2011). The Coastal America Foundation, which manages grant funds for the Corporate Wetlands Restoration Partnership, provided $290,000 in restoration grants in 2011 (Coastal America Foundation 2011). These investments are made for a wide variety of reasons, from a desire to meet corporate social responsibility goals or build positive relationships with federal enforcement agencies (NFWF 2013).

Private equity firms are investing institutional funds in wetland restoration, with the expectation of returns from the sale of mitigation credits (PEI 2012). Private forest owners may opt to undergo an improved forest management project in order to sell offsets on the California carbon exchange (Climate Action Reserve 2013). These types of private investments rely on incentives generated through other demand factors; wetland restoration is profitable because of the Clean Water Act, which requires mitigation for losses of aquatic resources. California's offset market is driven by AB32 regulations, while Philadelphia's green infrastructure investments are driven by the City's tax policy. The Philadelphia policy, in turn, is driven by the City's need to comply with its Clean Water Act TMDL—a regulatory driver.

Of the five demand factors we describe, no single factor operates independently of the others, and it is the linkages between these factors that make the restoration industry so complex.

Quantifying the Economic Benefits, Impacts, and Contributions of Restoration

Having reviewed a variety of programs driving U.S. ecological restoration, our next aim was to review available literature to understand the economic impacts of the restoration industry in the United States. The existing literature can be organized into two general categories: (1) economic benefits studies and (2) economic impacts and contributions studies. Economic benefits studies examine the economic benefit (often without accounting for opportunity or restoration costs), including market and non-market value, of restoration activities (e.g. MDFG 2014). Conversely, economic impacts and contributions studies describe how expenditures in a particular industry cycle through the economy and stimulate impacts in other industries. Many economic evaluations of restoration project proposals employ methods from both types of studies. However, it is important to note that benefits and contributions are different measures: the former focuses on the value produced, while the latter focuses on gross output and employment (DOI 2012).

The literature was also reviewed for information on the current size of the restoration industry. To date, there are no estimates of the size of the restoration industry at a national level. Many studies have looked at restoration on a regional (e.g. U.S. Gulf Coast; Kroeger 2012) or state level (Shropshire & Wagner 2009; Ellison et al. 2010; Moseley & Nielson-Pincus 2010; Industrial Economics, Inc. 2012). Those studies that have looked at a broader spatial scale have estimated total investments or spending in a particular segment of restoration work, such as total annual investments made by the mitigation and conservation banking industry (Environmental Law Institute 2007) or in river restoration (Bernhardt et al. 2005). Alternatively, some recent work has estimated total investments made by a particular agency or grant program (DOI 2012; Edwards et al. 2013).

Economic Benefits of Restoration

The long-term benefits associated with restoration are well documented, and include increased property values and local tax revenue (Acharya & Bennett 2001; Kiel & Zabel 2001; Bark et al. 2009; Isley et al. 2011), increased revenues associated with tourism and outdoor recreation (McCormick et al. 2010; Isley et al. 2011), increased fish and game revenues (Kruse & Scholz 2006; McCormick et al. 2010; Kroeger 2012), and avoided costs associated with improved ecosystem services (see Table 1; see Supp. Information 6 in Appendix S1 for more details). Because environmental assets tend to provide positive externalities and services for which there is no market, traditional price-based approaches cannot be used to assess their value (Barbier 2007). It is important to recognize that many of the environmental benefits associated with restoration programs will not show up in National Income and Product Account estimates (BEA 2014) because the goods and services are not typically bought and sold in markets.

The primary methods used to estimate the value of these benefits include (1) stated preference approaches, such as contingent valuation, which surveys the willingness to pay for a particular benefits, and (2) revealed preference approaches, such as travel-cost modeling or hedonic pricing, which assess the actual amount paid for a benefit or its proxy (Pascual & Muradian 2010). More details are given in Supp. Information 6 in Appendix S1.

Economic Impacts and Contributions of Restoration

Restoration investments also have a short-term economic and employment stimulus, which can be measured through economic impact and contributions analyses. The stimulating effects of increases in spending, in any industry as well as in the public sector, are the result of interdependencies among industries, whereby changes in demand in one industry can have ripple effects for suppliers and related businesses.

Government agencies and industry groups frequently use multipliers to calculate the *direct, indirect (business-to-business spending), and induced* (*household spending*) effects of new projects on a state or local economy (BEA 2012; see Supp. Information 7 in Appendix S1 for full description of these effects). These economic *impact analyses* describe the marginal economic impacts of changes in investment levels.

Table 1. Long-term economic benefits of environmental restoration.

Benefit	*Source*
Esthetics	
Increased property values	Isley et al. (2011), Bark et al. (2009), Kiel and Zabel (2001)
Increased tourism	Isley et al. (2011), McCormick et al. (2010)
Recreation	
Boating, swimming, water sports	Carson and Mitchell (1993)
Park visitation	McCormick et al. (2010)
Fish and game	
Fishery enhancement	Kroeger (2012), Barbier (2007), Kruse and Scholz (2006)
Wildlife enhancement	Vickerman (2013)
Ecosystem services	
Erosion control	Kroeger (2012)
Stormwater management	Valderrama et al. (2013)
Groundwater recharge	McCormick et al. (2010)
Surface water availability	Mueller et al. (2013), Milon and Scrogin (2006)
Water quality	Vickerman (2013), Kroeger (2012), Milon and Scrogin (2006)
Flood control	Kroeger (2012), Barbier (2007), Milon and Scrogin (2006)
Carbon sequestration	Vickerman (2013), Weinerman et al. (2012)

Contributions analyses use multipliers to estimate the portion of a region's economy that is attributable to an existing industry or program (IMPLAN Group 2013). Industry groups often use contributions analyses to illustrate the scale of a particular industry at a national level. Recent industry studies taking this approach include the oil and gas industry (PricewaterhouseCoopers 2011), the private forestry industry (F2M 2009), the green building and construction industry (Booz Allen Hamilton 2009), the environmental protection industry (Bezdek et al. 2008), and the outdoor active recreation industry (Southwick Associates, Inc. 2007), among others.

Economic and Employment Multipliers

Total demand multipliers calculate the amount of output, earnings, or employment in various industrial categories attributable to a capital investment in one or more related industries (BEA 2012). For example, an output multiplier of 2.5 would mean that for a $1 million investment in a given industry, all related industries experience a combined total of $2.5 million in increased output.

Because restoration is not limited to any single industry, but rather a mixture of industries, assessing the direct, indirect, and induced effects requires constructing a custom input–output model by weighting multipliers from multiple industries by their relative contribution to the restoration program or project of interest. Our review has determined that most of the analyses of the ecological restoration sector are articulated as case studies, particularly around specific geographic areas. We should note that the scale of economic contributions analysis affects the multiplier estimates because when effects are only measured within a small geographic area (e.g. county or region), jobs that are created outside of the area of analysis are not counted. Larger scales of analysis are expected to have higher multipliers than smaller geographic scales, as more leakage of jobs between jurisdictions is accounted for at larger scales.

Case Studies: Direct, Indirect, and Induced Economic Effects

Baker (2004) was the first to use economic multipliers to estimate impacts specific to the restoration industry. Baker collected information on all public grants and contracts for restoration project implementation, watershed assessments, and sediment inventories in Humboldt County, California, between 1995 and 2002. Economic multipliers for farm, forestry, and fishing products from the RIMS II (Regional Input–output Modeling System; see Supp. Information 7 in Appendix S1 for details) model were then applied to the total spent on each type of work to estimate the overall value-added. Direct employment estimates were based on a survey of the businesses and non-profits engaged in local restoration work. Employment multipliers from RIMS II were applied to the direct employment figures to estimate indirect and induced employment effects. Baker estimated that the restoration industry directly supported 160 full-time, private sector jobs in Humboldt County in 2002, and indirectly supported 270–480 private sector jobs, 37 public sector jobs, and 11 tribal jobs. In addition, spending on restoration projects resulted in over \$29 million in value-added within the County's economy (see Supp. Information. 7 in Appendix S1 for more information).

Shropshire and Wagner (2009) expanded this methodology to the state level in an assessment of Montana's restoration industry. Rather than attempting to tally every restoration project in the state and calculate total output and employment effects, the authors used a single mine remediation and riparian restoration project, representative of restoration projects in the state, to calculate multipliers that could be used to estimate impacts from other projects. Industries comprising the restoration composite model included construction, engineering services, government oversight, rail and truck transportation, legal and accounting services, hazardous waste handling, forestry support activities, and more.

Using the IMPLAN input–output model (Impact Analysis for Planning, IMPLAN Group 2014; see Supp. Information 7 in Appendix S1 for details), the authors estimated that 10.97 jobs were directly attributable to a \$1 million investment in the restoration project. The total number of direct, indirect, and induced jobs attributable to a \$1 million investment was 31.5, meaning the project had an employment multiplier of 2.87. Similarly, the authors found an overall output multiplier of 2.59, such that the state economy added an estimated \$2.59 million in value per \$1 million invested.

This study was followed in 2010 by an assessment of Oregon's restoration industry (Nielsen-Pincus & Moseley 2010), which has grown in parallel to an extensive timber industry, which supplies similar equipment and labor skill. The authors used a stratified sample of 99 Oregon Watershed Enhancement Board grants to create input–output models for a variety of restoration project types, including in-stream, riparian, wetland, upland, and fish passage restoration as well as for four different types of contracts. Employment multipliers were found to vary widely (from 1.48 to 3.8) depending on the type of contract. Output multipliers ranged from 1.6 to 2.59 depending on the type of work performed, with the greatest benefits to trade in fuel, wood products, rock, metal, and other building and landscaping products. The number of jobs supported by restoration activities also varied by project type, from an estimated 14.7 jobs per \$1 million invested for in-stream restoration to 23.1 jobs per \$1 million invested for riparian restoration. Employment multipliers ranged from 2.7 to 3.8 and output multipliers ranged from 1.9 to 2.4 for all project types (see Tables 2 & 3). A more recent estimate of restoration activity in Oregon (2001–2010) by Kellon and Hesselgrave (2014) found that \$411.4 million was invested in 6,740 watershed restoration projects, generating \$752.4–\$977.5 million in economic output and 4,628–6,483 jobs.

The Massachusetts Division of Ecological Restoration replicated these methods to estimate the economic impacts of four representative restoration projects on the state's economy (Industrial Economics, Inc. 2012). Cost information was used to populate an IMPLAN model for each project type, including recreation of a tidal creek/wetland system, wetland restoration (including dam removal), tidal wetland restoration, and dam removal. The number of jobs supported by these projects ranged from an estimated 9.9 per \$1 million invested for wetland restoration (with dam removal) to 12.9 jobs per \$1 million invested for tidal creek recreation. The authors attributed the smaller economic impact of these restoration projects relative to those in Montana and Oregon to the lesser ability of Massachusetts to meet restoration industry demand in-state.

On an agency scale, the U.S. Department of the Interior (DOI) estimated the economic impact of its own restoration investments by creating regional input–output models for a sample of nine restoration projects (DOI 2012). Contractors and program managers provided data on the labor, products and services used to implement each projects, and supplier and household impacts were estimated for the counties within commuting distance (60 miles) from the project site. There was a very wide variation in the local economic effects, ranging from 5.8 to 27.2 jobs per \$1 million invested and \$23,000 to \$5.7 million in total output gained. However, project size ranged from several thousand dollars up to \$25 million. Interior found that the impact of projects on local economies was most strongly affected by the type of restoration project, with some types of restoration requiring larger investments than others. However, the size and diversity of the local economy and the Interior's purchasing methods also affected the economic impact, suggesting that economic impacts are not comparable across different geographic scales.

Similarly, NOAA used economic multipliers to assess the economic impacts of its coastal habitat restoration grant program, as funded through the American Recovery and

Table 2. Variation in job impact estimates by project type and geographic scale. For estimates in Garrett-Peltier and Pollin (2009), see Heintz et al. (2009) for the methodology used to derive the multipliers.

Type of Restoration	*Jobs per $1 M Invested*	*Geographic Scale (State)*	*Source*
Forest, land, and watershed	39.7	National	Garrett-Peltier and Pollin (2009)
Invasive species removal	33.3	State	Edwards et al. (2013)
Grassland	13.0	County	Derived from DOI (2012)
Upland	15.0	State (OR)	Neilson-Pincus and Moseley (2010)
Wetland	6.8	County	Derived from DOI (2012)
Wetland	12.9	State (MA)	Industrial Economics, Inc. (2012)
Wetland	17.6	State (OR)	Neilson-Pincus and Moseley (2010)
Tidal marsh	7.1	County	Derived from DOI (2012)
Fish passage	10.4	State (MA)	Industrial Economics, Inc. (2012)
Fish passage	15.2	State (OR)	Neilson-Pincus and Moseley (2010)
Fish passage/dam removal	18.2	State	Edwards et al. (2013)
Dam removal	10.3	State (MA)	Industrial Economics, Inc. (2012)
Dam removal	20.5	State (CA)	Kruse and Scholz (2006)
River	9.7	County	Derived from DOI (2012)
In-stream	14.7	State (OR)	Neilson-Pincus and Moseley (2010)
In-stream	31.5	State (MT)	Shropshire and Wagner (2009)
Hydrologic reconnection	14.6	State	Edwards et al. (2013)
Riparian	19.0	State	Edwards et al. (2013)
Riparian	23.1	State (OR)	Neilson-Pincus and Moseley (2010)
Oyster reef	16.6	State	Edwards et al. (2013)
Oyster reef	20.5	County	Kroeger (2012)

Table 3. Employment and output multipliers by industry. For estimates in Garrett-Peltier and Pollin (2009), see Heintz et al. (2009) for the methodology used to derive the multipliers.

Industry	*Employment multiplier*	*Output multiplier*	*Geographic scale*	*Source*
Oil and gas	Approximately 3	—	National	PricewaterhouseCoopers (2011)
Crop agriculture	2.33	—	National	Garrett-Peltier and Pollin (2009)
Livestock	3.34	—	National	Garrett-Peltier and Pollin (2009)
Outdoor recreation	1.97	—	National	Southwick Associates, Inc. (2012)
Conservation	3.4	2.4	National	Southwick Associates, Inc. (2013)
Restoration				
	1.48	1.60	State	Edwards et al. (2013)
	2.7–3.8	1.9–2.4	State	Neilson-Pincus and Moseley (2010)
	1.59–1.78	1.68–1.83	State	Industrial Economics, Inc. (2012)
	2.87	2.59	State	Shropshire and Wagner (2009)

Reinvestment Act (Edwards et al. 2013). Grant recipients were required to report restoration expenditures organized by NAICS codes. The authors used expenditure data from 44 sampled projects to create input–output models for six different project types, including marine debris removal, fish passage/dam removal, hydrologic reconnection, invasive species removal, oyster reef restoration, and riparian restoration. The number of direct, indirect, and induced jobs supported by these projects ranged from 14.6 per $1 million invested for hydrologic reconnection to 33.3 per $1 million invested for invasive species removal.

Challenges to Scaling Up Restoration Economy Studies

The case studies reviewed above highlight a number of key challenges to scaling up the economic impact estimates to the national level in order to describe the size of the restoration economy and the number and types of jobs it supports. First, the direct, indirect, and induced economic effects are highly variable at different geographic scales, across different geographic areas, and among different types of projects. Second, while the employment multipliers provide an estimate of the quantity of jobs created at a given level of investment, they do not describe job quality (see Supp. Information 8 in Appendix S1). We are unable to draw conclusions about the reliability, wages, and benefits of employment in the restoration industry from the direct, indirect, and induced job figures.

Variation in Estimates

The wide variation of employment effects and multipliers across these studies and others (e.g. see Davis et al. 2011; Louisiana Workforce Commission 2011; Kroeger 2012) is most strongly influenced by the type of restoration project evaluated, but is also affected by geographic location (Table 2). Different regions in the United States have wide-ranging average costs for wetland and stream restoration projects, relating to different patterns and causes of ecosystem degradation, local topography and climate, and local and state regulatory environments (King & Bohlen 1995). States may have different compensation standards that affect labor costs, and rules governing collective bargaining and public procurement that can have large impacts on the shares of labor and equipment that are locally supplied (King & Bohlen 1995; DOI 2012). Shropshire and Wagner (2009) caution that employment multipliers from Montana should not be used for privately funded restoration projects or projects in other states because the costs of government oversight are not comparable. Land prices and topography also influence cost; median costs for stream restoration are highest in the southeastern United States compared with the rest of the nation (Sudduth et al. 2007), while wetland restoration costs were found to be significantly higher in California (King & Bohlen 1995).

Even within a particular geographic area, employment and economic impacts are likely to vary across different types of projects. In Oregon alone, the direct, indirect, and induced employment effects of restoration varied from 14.7 to 23.1 jobs per $1 million invested depending on the type of ecosystem being restored (Neilson-Pincus & Moseley 2010). Edwards et al. (2013) found a broad range of employment effects from the six types of restoration projects evaluated. Invasive species control produced far more positive employment effects than any of the other restoration activities evaluated. Even among wetland restoration projects, there is wide variation in the relative share of labor, materials, and equipment inputs required, depending on the type of wetland (King & Bohlen 1995). Thus, the economic and employment multipliers for restoring a freshwater emergent wetland would not be applicable to a tidal marsh wetland, even in the same geographic region.

Finally, impact and contribution estimates are highly sensitive to the geographic scale at which impacts are measured. Some studies used county-level multipliers to estimate highly local impacts, while others used state-level multipliers. The state-level multipliers are inherently larger because impacts that leak beyond the borders of any individual county or region are more likely to be captured by the state economy.

Comparison to Other Industry Studies

Industry studies from a variety of other industries were collected and reviewed to supplement our assessment of best research practices, and to provide context for estimates of the economic contributions of the restoration industry. Industries reviewed included the oil and gas industry (PricewaterhouseCoopers 2011), the private forestry industry (F2M 2009), the green building and construction industry (Booz Allen Hamilton 2009), the environmental protection industry (Bezdek et al. 2008), and the outdoor active recreation industry (Southwick Associates, Inc. 2007), among others. All of the studies reviewed used an economic contributions analysis approach. However, several did not provide disaggregated data that would allow for the derivation of output and employment multipliers. In addition, several studies did not include induced effects in the total contributions estimates.

The employment multipliers of restoration projects hold up in comparison to those of other industries, to the extent that these values can be compared. As the only existing estimates of restoration industry contributions are derived from state-level multipliers, they are not directly comparable to the national-level estimates of other industries. However, state-level multipliers do not account for leakage to areas outside of the state and are expected to be lower than national-level multipliers for the same types of work.

The American Petroleum Institute estimates that the oil and gas industry has an employment multiplier of approximately 3.0 at the national level (PricewaterhouseCoopers 2011), which falls within the range of employment multipliers found for all forest and watershed restoration projects at the state level, in Oregon (Nielsen-Pincus & Moseley 2010). Crop agriculture has a national employment multiplier of 2.33, while livestock has an employment multiplier of 3.34 (derived from Garrett-Peltier & Pollin 2009). The outdoor active recreation industry has an employment multiplier of 1.97 (derived from Southwick Associates, Inc. 2012).

Overall, the employment multipliers within the restoration industry and in other industries are fairly comparable (Table 3). Lower employment multipliers for some types of restoration projects may be due to the large number of direct jobs involved in the restoration activity. Total employment effects may better represent the impact of these projects. Infrastructure investment studies conducted by the Political Economy Research Institute at the University of Massachusetts suggest that the employment effects of restoration projects may actually be greater than those in the oil and gas industry, which supports only about 5.3 jobs per $1 million invested (Pollin et al. 2009). In contrast, restoration industry literature has found total employment effects ranging from 10.4 to 39.7 jobs per $1 million invested. It is important to remember, however, that geographic scale and location also influences the magnitude of the multiplier effect, as described earlier, and that direct comparisons between values must be made with caution.

Discussion

Based on a thorough review of the literature, it is clear that the United States has a highly active restoration industry, contributing growth and jobs to the national economy in the short-term as well as long-term value and cost savings. Despite the commonly held idea that environmental regulations like the Clean Water Act and Endangered Species Act impede economic growth in certain sectors (e.g. see work by Sunding & Zilberman 2002), there is ample evidence that the public and private investments driven by these regulations have a stimulating effect on economic output and employment in the restoration-related industries that we have highlighted.

Federal appropriations for restoration-related programs can be conservatively estimated at $1.9 billion per year—the average level of appropriations identified between 2011 and

2013—and at $72 million per year at the state level. These estimates are extremely conservative because they do not include the appropriations that federal and state agencies receive for general operations and procurement not tied to a particular restoration program or project. Public and private investments linked to compensatory mitigation total an estimated $3.8 billion per year (Environmental Law Institute 2007), and non-profit investments in natural resources and wildlife preservation and protection are estimated to exceed $4.3 billion annually (Southwick Associates, Inc. 2013).

Restoration investments appear to have particularly localized benefits, which can be attributed to the tendency for projects to employ local labor and materials (Shropshire & Wagner 2009; Davis et al. 2011; Weinerman et al. 2012). This parallels previous work by Hibbard and Lurie (2006), who discovered that 80 cents of each dollar invested in local watershed councils stays within the county where it is expended. Although contractors and workers may experience seasonal and inter-annual fluctuations in income and employment, like their counterparts in the construction industry, preliminary evidence indicates that restoration jobs are well compensated in comparison to average wages (Shropshire & Wagner 2009).

Available case studies demonstrate strong evidence of positive economic impacts resulting from restoration investments (both publicly and privately funded), as well as highlight the challenge of scaling up existing research to a national estimate of the size of the restoration economy. While large-scale restoration investments stimulate output and employment in a wide range of other industries (through supplier and household spending effects), the literature also indicates that the economic multipliers used to estimate these ripple effects are highly sensitive to the type of ecosystem undergoing restoration and the geographic scale of the economic analysis.

It is important to note several caveats of our analysis, which point to areas of further needed research. First, we must note that the studies that we have surveyed have not individually or collectively performed in-depth comparative accountings of their findings with the economic costs of restoration programs or output lost in other sectors. This type of comparative accounting is an area in need of further research.

Second, a disproportionate number of the studies we analyze focus on coastal and estuarine restoration. This is echoed in a meta-analysis of the socioeconomic benefits of restoration studies by Aronson et al. (2010), who found that ecological restoration research is significantly skewed toward forest and aquatic ecosystems. We suspect that this is either the result of the increasing interest in the threats to coastal habitats (e.g. Conathan et al. 2014), or the focus of a large fraction of real-world restoration activity. It is evident that more terrestrial analyses need to be performed in order to better understand what appears to be either a bias in restoration focus or a bias in the literature studying this topic.

Third, it is evident that appropriations data are extremely difficult to track in a meaningful way. Our data are widely distributed and our sample of state programs with full available data is relatively small. Significant additional research or a concerted effort on the part of federal and state agencies is needed to accurately and systematically quantify and delineate public expenditures on ecological restoration. Part of this work should endeavor to analyze restoration program goals, locations, and authorities, as well as evaluate funding programs with regard to demand driver categories (e.g. the types we have established in this article), program lifespans, and the frequencies and geographic distribution of each program's funding efforts.

Finally, multipliers developed for the county, regional, or state level cannot be extrapolated up to larger geographic areas. Further research is needed to develop national economic multipliers for the restoration industry in order to understand the total impact that restoration investments—including private investments that represent new and additional sources of restoration funding—have on the national economy.

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Supporting Information

The following information may be found in the online version of this article:

Appendix S1. Information 1: Note on the Green Economy.
Information 2: Defining restoration
Information 3: Restoration Drivers
Information 4: Other Restoration Program Databases
Information 5: Programs Database
Information 6: Economic Benefits of Restoration
Information 7: Methods
Information 8: Job Quantity versus Quality

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