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Is the tide is changing? Assessing costs and benefits of dam removal and river restoration: a case study in Florida

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Abstract

Nationwide, dam removal discussion is fueled by the increased interest in environmental restoration and high dam maintenance and retrofit costs (Stanley and Doyle 2003, Smith 2006). Unlike the debate in other states, for Florida's Kirkpatrick Dam impounding Ocklawaha River, environmental protection arguments are made by both the dam preservation supporters and their opponents. The supporters are interested in bass fishing in the impoundment, while the opponents argue for improving migratory fish passage and upstream river ecology by removing the dam. This study estimates of the value visitors derive from recreation and the economic contribution of river-based recreation to explore the economic arguments related to the recreational use of the impounded vs. natural stretches of the river and examine potential economic implications of the dam removal. We utilize a combination of site visitation data collected by government agencies and intercept visitor survey responses (n = 340). By examining the differences in the survey responses among the visitors engaged in different types of recreational activities, residing in different counties, visiting different recreational locations, and having different income status, we examine distributional issues associated with preserving and removal of the dam.

Introduction

Dams play an important role in the economy of different regions in the U.S. and in the world, delivering hydropower, supplying irrigation and drinking water, and providing for recreational opportunities and navigation (Tullos et al. 2009, Brown et al. 2009). In the U.S. the number of dams is estimated at 2.0 to 2.5 million (USEPA 2016), and more than 87,000 large and/or hazardous dams are listed in the National Inventory of Dams maintained by the U.S. Army Corps

Engineers (USACE 2016), with the majority of dams constructed for the purposes of recreation (31.9%), flood control (17.1%), fire protection (12.9%), irrigation (9.3%), or water supply (7.2%) (USACE 2016). Many of the dams were constructed prior to 1979, and estimated 75 to 90 percent of dams no longer serve their functional purposes, with their structures becoming obsolete (USEPA 2016; USACE 2016).

For many dams, environmental impacts of their construction were not comprehensively analyzed at the time of construction (Shuman 1995; Graff 1999; Null et al. 2014). Currently, the impacts of dams on rivers and watershed ecosystems are documented, even though variation in local conditions apply (WCD 2000; USEPA 2016). Dam construction impacts upstream and downstream stretches of the river, affecting terrestrial and aquatic ecosystems, reducing floodplain productivity, and altering channel development. Inundation results in sedimentation, greenhouse gas emission, and nutrient releases. Fragmentation of the rivers and flow blockages hinder migration of organisms, impacting populations of some species. Under a changing climate, such blockages can potentially prevent species re-distribution and adaptation (USEPA 2016; Nilsson et al. 2005; WCD 2000).

Dam removal discussions are fueled by the increased interest in restoration and environmental mitigation, aging dam infrastructure and related safety concerns, low economic benefits generated by the dam, and high maintenance and retrofit costs (Stanley and Doyle 2003, ICF Consulting 2005, Smith 2006, Shuman 1995). More than 1300 dams have been removed in the U.S. as of 2015 (Gilman 2016, citing American Rivers conservation group), with a majority (865) removed in the last 20 years, indicating an accelerated rate of dam removal (Nijhuis 2015). Overall, given the aging dam infrastructure and increased societal value of restored or free-flowing rivers, public interest in dam removal is expected to continue (Bellmore et al. 2016).

The consequences of dam removal are site-specific and depend on the size, reservoir water storage, composition of residual biota, depth of reservoir, sediment storage and movement in the reservoir, placement of outlets, and other factors (Stanley and Doyle 2003, Smith 2006, Brown et al. 2009). Recolonization of a restored river by the fish species previously residing upstream or downstream from the dam can be quick, and migratory fish species are expected to move into formerly occupied stretches of the river, though uncertainty remains about the specific species composition at certain locations (Stanley and Doyle 2003, Smith 2006). Other potential consequences that should be accounted for include changes to river channel morphology above and/or below the dam; potentially degraded water quality during the drawdown for dam removal; the need to re-contour floodplain to assure floodplain function after dam removal; spread of invasive species, and the need to manage revegetation to prevent soil erosion following the dam removal (Shuman 1995, Bellemore et al. 2016). All consequences of dam removal should be assessed prior to dam removal.

Despite the significant number of dams constructed, planned, or removed, the number of studies examining the economic and ecological consequences of dam management is relatively small, highlighting the need for additional research in this area (ICF Consulting 2005; Bellmore et al. 2016). Bellmore et al. (2016) estimated that only 9% of all U.S. dam removal projects had been evaluated from physical, biological, or water quality perspectives; and Kibler et al. (2011) states that the economic outcomes of only 5% of dam removal projects have been published in the scientific literature.

Thirteen economic studies in the U.S. were identified that focused on evaluating the impacts of dam construction, management, or removal on the ecosystem services provided by the streams, such as recreation or wildlife habitat (Table 1). Seven out of these studies examined the impacts of dam construction, management, or removal on *tourism and recreation activities*, and they generally concluded that free-flowing rivers provide greater recreational benefits than impounded rivers. Five of these studies focused on rivers in Pacific Northwest (Washington and Idaho), one study focused on Great Lakes region (Michigan), and one study examined a river in New England (Main). The most researched river is the Lower Snake River in Washington, with four studies examining if the potential removal of dams on this river improves migratory fish passage, and the related effects on reservoir- versus river-based recreation. All four studies concurred that dam removal would increase recreation and its economic value (Loomis 2002; McKean et al. 2005, 2010, 2012). Similar conclusion was reached in another study that focused on a proposed dam in Idaho. The study estimated that if the proposed dam reduces fish catch or fish size by half (which was perceived as a realistic scenario by experts), this would lead to approximately one million dollar reduction in fishing benefits (Loomis et al. 1986). Further, a survey of anglers in Maine showed that removal of the Edwards dam on the Lower Kennebec River was perceived by anglers to increase the number and types of fish in the river, and resulted in increased spending associated with the restored fishery (Bohlen and Lewis. 2009). Finally, a study conducted in Michigan considered alternative management regimes of two hydropower dams to better mimic natural river flow conditions. The study found that the combined benefits from improved fishing and reduced greenhouse gas emission associated with more natural river flow outweigh the increased cost of electricity generation (Kotchen et al. 2006). Overall, the studies focusing on the impact of dam construction, management, or removal on recreation found improved fishing and other recreational opportunities on free-flowing rivers.

Three of the thirteen economic studies focused on the effects of dam removal on nearby *residential property values*. The studies focused on rivers in Main and Wisconsin. Dams and associated impoundments can increase the value of water-front properties. However, this positive relation can be reversed if impounded rivers offer little recreation opportunities and low amenity values. For example, Bohlen and Lewis (2009) found that prices were lower for properties closer to the Penobscot River in Maine, and concluded that dam removal could improve river conditions and increase riverfront property prices. In another Maine watershed, the Kennebec River, Lewis et al. (2008) found a positive effect of dam removal on the value of properties located next to the dam, as well as properties upstream. Finally, a study in Wisconsin compared the prices of the properties next to impoundments with those next to free-flowing streams, and found no difference. Moreover, non-frontage properties showed an increase in price for the locations close to the free-flowing streams, in contrast to the non-frontage properties in proximity to impoundments (Provencher et al. 2008).

Recreation and property values are only two components of the total economic values of rivers and reservoirs, with other components such as the value of preserving the resource for future generations and the value of providing habitat for fish and wildlife (e.g., Loomis et al. 2000). Two studies conducted in the Washington and Puerto Rico attempted to assess *the total economic value* of free-flowing rivers, as compared with rivers impounded by dams. In one study, it was found that dam removal and restoration of salmon and steelhead population on the Elwaha River in Washington was highly valued by the residents, not only in the State of Washington, but also in the rest of the nation (Loomis, 1996). In the other study, it was found that Puerto Rico residents were willing to pay for protecting ecological integrity and avoiding water withdrawals and dam construction on the Rio Mameyes and Rio Fajardo (Gonzalez-Caban and Loomis 1997).

Finally, a recent study evaluated the tradeoffs associated with dam removal in California's Central Valley. The study examined reductions in hydropower generation and water supply given additional miles of river restoration, accounting for climate change projections and population growth. The study concluded that some of existing rim dams can be removed, though removing all dams is not economically optimal, resulting in significant cost of alternative power generation and water supply provision (Null et al. 2014).

Note that this review focused only on the studies conducted in the U.S. and its territories. More economic studies can be found focusing on dam construction and removal in other countries (e.g., Ziv et al. 2012; Richter et al. 2010; Moore et al. 2010; Mattmann et al. 2016).

Overall, given the current trends in dam construction in developing countries, and dam removal in the U.S., the assessment of impacts of dam construction and removal remains an extremely important topic, with more economic studies on the topics needed to inform stakeholders of potential tradeoffs.

Table 1. Summary of Economic Studies Evaluating the Impacts of Dam Construction or Removal in the U.S. (in chronological order)

	Reference	Dam Location	Dam Examined	Key Benefits of Free-Flowing Stream	Key Benefits of Dam Construction Projects	Method	Economic analysis
1	Loomis et al. 1986	Idaho	Proposed hydropower dam on Henry's Fork of the Snake River in eastern Idaho	A range of potential impacts of dam construction identified, from reductions in fish populations to elimination of recreational fishing on some portion of the stream.	Hydropower production	Travel Cost and Contingent Valuation Methods	A 50% reduction in fish catch due to a dam would result in an annual loss of $920,000 in fishing benefits. If, instead, a 50% reduction in size of fish caught occurs as a result of a dam, the annual loss in fishing benefits would be $1.07 million.
2	Loomis, 1996	Washington	Removal of Elwha and Glines Canyon dams on the Elwha River, Washington	The dams were originally built without any fish passage facilities, and they block the Elwha River to migrating salmon. Dam removal would result in substantial increases in salmon and steelhead populations.	Hydropower production	Contingent valuation method	The mean annual willingness to pay for removing the two dams and restoring the ecosystem and the anadromous fishery is $59 per household in Clallam County, $73 per household for the rest of Washington, and $68 per household for households in the rest of the United States. The aggregate benefits to residents of the State of Washington is $138 million annually for 10 years and between $3 and $6 billion to all U.S. households.
3	Gonzalez-Caban and Loomis, 1997	Puerto Rico (U.S. territory)	Preserving instream flows in the Rio Mameyes and avoiding a dam on the Rio Fajardo	Dam construction and water withdrawals would impact the ecological integrity and riparian zone viability in the Rio Mameyes and Rio Fajardo.	Water withdrawals would supply the present and future needs of the cities of Luquillo, Rio Grande, Canavanas, Lofza, San Juan and the proposed hotel complex close to Rio Mar.	Contingent valuation method	The annual value per household in the sample was estimated to be $27 for the scenario preventing 10 mgd extraction of water from the Rio Mameyes and implementing an alternative program of repairs of the water distribution system lines and in-home water conservation program. Households would also pay $28 per year to avoid a dam on the Rio Fajardo and to implement an alternative program (dredging of the two major reservoirs to the San Juan metropolitan area). For a combined program protecting both rivers, average household WTP was $31.
4	Loomis, J. 2002	Washington	Removal of four dams on the Lower Snake River (restoring the 225 km of river)	River-based recreation	Reservoir-based recreation; hydro-power production; and barge transportation	Travel cost method	The annualized benefits for the dam removal scenario is estimated at $310 million. This gain in river recreation exceeds the loss of reservoir recreation. However, government studies estimate the annual hydropower losses associated with dam removal to be $271 million annually. Including the dam removal cost and foregone barge transportation, the costs rise to $360 million. River recreation would cover a large portion of these costs but not all of them.
5	McKean et al. 2005	Washington	Potential removal of dams / impoundments on lower Snake River, eastern Washington	Support of anadromous fish passage / habitat; river-based recreation	Barging, hydroelectric power, and flatwater recreation	Travel cost method	The upper bound on the current non-fishing recreational benefits (without dam removal) is nearly $7.2 million per year. This estimate is below the values of recreation associated with dam removal scenarios (as estimated in the past studies).
6	Kotchen et al. 2006	Michigan	Change in the streamflow of Manistee River to match the flow of	Recreational fishing benefits (in the river and Lake Michigan) and air quality benefits	Increase in the cost of electricity production	Benefit transfer model (to estimate the air quality benefits);	The aggregate benefits from the changed management regime ranges from $806.2 to $985.1 million per year, and the producer costs are $310.6 per year.

	Reference	Dam Location	Dam Examined	Key Benefits of Free-Flowing Stream	Key Benefits of Dam Construction Projects	Method	Economic analysis
			freeflowing river, as a result of changes in operation of two hydroelectric dams (implemented in 1994)			replacement cost model (to estimate the increased cost of electricity production); travel cost model (the value of improved recreational fishing)	
7	Lewis et al. 2008	Main	Three dams examined are (1) the Edwards Dam, Kennebec River, removed in 1999; (2) the Ft. Halifax Dam, a dam at the mouth of the Sebasticook River where it meets the Kennebec; and (3) the Lockwood Dam, the main stem of Kennebec.	Edwards Dam, post-removal: (1) anadromous fish, including Atlantic salmon, have returned to the river above the dam site; (2) benthic aquatic insect populations—a key indicator of ecosystem health used to document compliance with water quality standards—appear to be growing dramatically; (3) Recreation on the river in the form of fly-fishing, canoeing, and kayaking has also grown.	After the removal of the Edwards Dam, upstream dams faced the need to build fish passage. Lockwood Dam provides a total generating capacity of nearly 7 MW, and a state-of-the-art fish lift was recently constructed at the site at a cost of $2.4 million. Ft. Halifax dam has a generating capacity of 1.5 MW; and the costs of providing fish passage at this small hydropower site have made continued operation no longer cost effective. Removal of the dam would eliminate its impoundment with its recreational and aesthetic resources.	Hedonic property value methods	For Edwards Dam, the property value was found to be smaller closer to the dam. However, the penalty is smaller post-dam removal than it was pre-dam removal. Before the dam was removed, a homeowner, on average, was willing to pay an additional $2,000 to be ½ mile away from the dam. After removal, the willingness shrinks to $134. Properties near the remaining dams have lower value than do properties farther away from the dams. The magnitude of this penalty has also gotten smaller since the Edwards Dam, nearly 20 miles downstream, was removed. Improved fisheries and water quality after the removal of Edwards Dam can potentially increase the desirability of the property closer to the river.
8	Robbins et al. 2008	Main	Lower Kennebec River, post-Edwards Dam removal	Following the Edwards Dam removal in 1999, return of anadromous fish, including Atlantic salmon, was observed. Recreation opportunities on the river in the form of fly-fishing, canoeing, and kayaking, increased.	Dam removal resulted in the potential loss of reservoir-based recreation, as well as in the loss of hydropower production (though of only marginal value).	A mail survey of the members of Maine Trout Unlimited (TU) and ⁄ or the Maine Coastal Conservation Association	Anglers are spending more to visit the restored fishery, a direct indication of the increased value anglers place on the improved fishery. Anglers are also willing to pay for increased services related to the fishery. Dam removal was beneficial according to 83.53% of respondents, 59.91% of respondents felt that water quality had improved since removal, and 65.84% of all respondents reported that they felt the numbers and types of fish in the river had increased.
9	Provencher et al. 2008	Wisconsin	Comparison of the three types of sites: those where a small dam remains intact (4 sites), those where a small dam was removed (6 sites), and those	Environmental integrity	The primary value of small impoundments associated with the dams is their aesthetic/scenic value, potentially benefitting waterfront properties	Hedonic property value methods	Shoreline frontage along small impoundments shows no noticeable increase in residential property price compared to frontage along free-flowing rivers. Nonfrontage property located in the vicinity of a free-flowing river is more valuable than identical property located in the vicinity of an impoundment. The results are consistent with the conclusion that removing a dam does little harm to property values in the short run (2

	Reference	Dam Location	Dam Examined	Key Benefits of Free-Flowing Stream	Key Benefits of Dam Construction Projects	Method	Economic analysis
			where a river or stream has been free-flowing for at least 20 yr (4 sites).				year) and serves to increase property values in the long run, as the stream and associated riparian zone mature to a "natural" free-flowing state or is managed as a desirable open space.
10	Bohlen and Lewis. 2009	Main	Removal of the two lowermost dams on the Penobscot River (Veazie and Great Works), and the decommissioning of a third dam (Howland Dam), where an innovative bypass channel would be installed, permitting fish passage.	The Penobscot River supports the largest remaining population of wild Atlantic salmon in the United States. Dams and other barriers to fish migration pose a significant threat to the continued survival of salmon and other diadromous fishes in these waters. Negative impact of the dams on waterfront properties is hypothesized.	Hydropower production	Hedonic property value analyses	A negative relationship between proximity to the Penobscot River and housing prices was found. Until quite recently, Maine's rivers were badly polluted, often smelled bad in the summer, and offered few recreational opportunities. Local residents understandably placed little value in proximity to the river. Dam removal might reduce this effect if the project results in improved river conditions.
11	McKean et al. 2010	Idaho / Washington	Potential removal of dams / impoundments on lower Snake River, eastern Washington	Support of anadromous fish passage / habitat; river-based recreation	Barging, hydroelectric power, and flatwater recreation	Travel cost models	Consumer surplus per angler per trip on the reservoir was $30.06. In comparison, the benefits estimate for fishing on the unimpounded river was $71.84, for a net increase of $41.78 per person per trip. However, the frequency of trips was expected to drop by 35%, from 19.6 to 12.7 trips per year. Still, fishing benefits are expected to increase by $2.52 - $3.87 million for the restored river.
12	McKean et al. 2012	Washington	Potential removal of dams / impoundments on lower Snake River, eastern Washington	Support of anadromous fish passage / habitat; river-based recreation	Barging, hydroelectric power, and flatwater recreation	Travel cost models	Current non-fishing recreational benefits (<u>without</u> dam removal) is $46 - $90 per person per trip. This estimate is below the values of recreation associated with dam removal scenarios and estimated in the past studies.
13	Null et al. 2014	California	Potential removal of rim dams in California's Central Valley	Habitat improvement / river restoration	Water supply and hydropower production	An economic-engineering optimization model is used to evaluate water storage and scarcity from removing dams. A climate model for a 30-year period centered at 2085, and a population growth scenario for year 2050 water demands represent future conditions.	Removing all rim dams is not beneficial for California, but a subset of existing dams are potentially promising candidates for removal from an optimized water supply and free-flowing river perspective.

Study Area

The history of the Kirkpatrick dam and Rodman reservoir started in the 1800s, when the idea emerged of constructing a cross-Florida canal to allow ship passage from the Atlantic Ocean to the Gulf of Mexico, boosting economic development in the state. In the 1930s, the U.S. Army Corps of Engineers identified the optimal path for the cross-Florida passage between Jacksonville and Yankeetown, involving significant changes to the St. Johns, Ocklawaha, and Withlacoochee Rivers to be connected by an approximately 100-mile long channel across the state. The construction began in 1935 and after a temporary suspension restarted in 1964. In response to fierce opposition by environmental groups concerned about the impact of the project on Florida's natural resources, the construction was stopped in 1971. The project was de-authorized in 1991. Later, the 110-mile corridor of land that was originally set aside for the canal construction became the Cross Florida Greenway State Recreation and Conservation Area (often referred to as Cross Florida Greenway). In 1998, the Greenway was officially named after Marjorie Carr, who led the effort to stop the cross-Florida canal construction (Noll and Tegeder, 2015; FDEP 2001). The Cross Florida Greenway provides ample recreational opportunities, and the most recent estimated annual economic impact of recreation was $74.3 million (Governor Rick Scott 2016).

Before the cessation of construction in 1971, part of the work for canal construction was completed, including Buckman Canal and Lock (connecting Ocklawaha and St. Johns River), Eureka Dam, and Rodman Dam, later renamed the Kirkpatrick Dam. While Eureka Dam was never closed, the Kirkpatrick Dam impounded the Ocklawaha River. The impoundment significantly modified the hydrology and ecology of the River and its tributaries. The dam blocked the flow of the Ocklawaha River, raising the height of the river, flooding the surrounding areas, and reducing the velocity of the river current and the volume of flow. As a result, over 20 springs (Lewis, personal communications) and approximately 7000 acres of seasonally flooded forest wetlands were permanently flooded, making these sites unavailable for land based recreation. Kirkpatrick Dam also prevented or complicated the upstream passage of fish and aquatic animals (such as channel catfish, striped bass, and manatees), some of which are classified as threatened or endangered. Furthermore, the impoundment resulted in changes in bird communities and fragmentation of wildlife corridors, altering wildlife species utilization of the area. The dam also impacted the movement of sediment and discharge flow to downstream portions of Ocklawaha River and the St. Johns River. Finally, the Dam impacted the ecosystems in the Silver River and Silver Springs and the upstream portions of the Ocklawaha River (Shuman 1995, FDEP 2002, cited by Nosca 2011, Lewis 2015).

The changes in the aquatic ecosystems in the Ocklawaha–Silver River system resulting from the dam and reservoir construction led to changes in recreational experiences and tourist visitation patterns. Fish diversity became limited in the upstream portions, particularly at Silver Springs (Lewis 2015). Changes in the Springs' ecosystems, caused by the reduction of the number and diversity of fish, along with the potential impacts of nitrogen loading and flow decrease, has contributed to the changes in the clarity and color of Silver Springs water, impacting the snorkeling, swimming, and glass bottom boat ride experiences of visitors.

At the same time, in the years since the dam construction, the reservoir developed its own altered ecosystems, providing habitat for multiple species of fish, birds, and other wildlife. Fishing and motorized and non-motorized boating opportunities are available at Rodman Reservoir, which became a preferred location for bass fishing tournaments and other reservoir-based recreation. For example, in 2016, the reservoir was included in the top ten lakes for bass fishing nationwide (Bass Master 2016).

More than forty years after canal construction project ceased, there are still opposing opinions about the future of the Kirkpatrick Dam and Rodman Reservoir, with some calling for breaching or removal of the dam, and others defending the maintenance of the dam on the ground of economic benefits provided by reservoir-based recreation. Further studies examining the potential economic impacts of Ocklawaha River restoration and Kirkpatrick Dam removal/breaching on recreation and tourism in the region are needed to help find an acceptable solution to the long-standing controversy.

Objectives and Methods

This study aims at examining the value of recreational experiences on the Ocklawaha River and Rodman reservoir given alternative management regimes, and economic contributions of river- and reservoir-based recreation to the local economy. Specific objectives are to: (1) examine the recreational use of the Ocklawaha and Silver Rivers and Silver Springs; (2) assess the direct and indirect economic contributions to the local economy associated with recreational visitor spending; and (3) estimate visitors' willingness to pay for recreational uses of the resource.

This study focuses on the recreation along the Middle and Lower Ocklawaha River upstream and downstream from Kirkpatrick Dam, Rodman Reservoir, Silver River, and Silver Springs. Similar to previous studies (e.g., Loomis 1996, 2002; McKean et al. 2005, 2010, 2012), we use visitor surveys to estimate the economic values of recreation. This document focuses on Phase I of the study, focusing on visitation during drawdown management regime of the Rodman Reservoir. Phase II of the study will be conducted during "normal" regime in winter – spring 2017.

The survey responses are used to examine the primary types of recreational activities, visitor expenditures, and visitor opinions about the river management. The economic contributions of river- and reservoir-based recreation to the local economy was assessed using a regional economic model (*IMPLAN*), focusing on estimating the value added (which is analogous to regional Gross Domestic Product), taxes collected, and full- and part-time jobs supported (Mulkey and Hodges 2000).

The targeted access points for the visitor survey were identified based on past visitation numbers provided by the state and local agencies (Florida Department of Environmental Protection and Marion County's Parks and Recreation), discussions with environmental group members, and a review of existing studies. Five access points were selected as survey sites. A set of questions was developed by the research team with feedback from the representatives of environmental groups, recreational businesses, and state agencies. The questionnaire was reviewed and approved by the UF Institutional Review Board to assure compliance with ethical standards for human subjects research. Survey interviews were conducted by the UF/Florida Survey Research Center. As an incentive, the respondents were offered a key chain with the UF logo, or a gator pin. The survey was conducted for selected days during the reservoir drawdown period with the goal of collecting a statistically representative sample of responses.

Results

A total of 340 responses were collected at 5 locations (Table 2). The responses were collected over weekends (64%) and weekdays (36%).

Table 1. Survey locations and number of responses

Location	Number of Responses	Percent Responses
Locations around Rodman Reservoir (total = 207)		
Eureka West	76	22.4%
Kenwood Landing	54	15.9%
Kirkpatrick Dam	77	22.7%
Upstream Oklawaha River Locations (total = 133)		
Rays Wayside	60	17.7%
Silver Springs	73	21.5%
Overall Total	**340**	**100.0%**

Survey respondents were slightly older, with a greater percentage of male respondents, compared with the Florida population as a whole. Specifically, 70% of the respondents were male (compared with 48.3% mail residents in the state as a whole, U.S. Census 2015). Respondents' age ranged from 18 to 93 years, with 37.5% of respondents being 62 and over (compared with 28.0% for the state as a whole) (Table 2). Educational attainment and income level of the visitors was generally comparable with the Florida population. More than half of the respondents had at least some college education, and among those who responded to the question about their income, majority had household income of $50,000 or above (Tables 3 and 4). Further, 42% were employed full-time, and 38% were retired.

Table 2. Age: Survey Respondents and Florida Population

Age	Survey Respondents (N = 336) (%)	Florida Population (18 years and over) (%)*
18 years and over	100.0%	100.0%
21 years and over	97.9%	95.1%
62 years and over	37.5%	28.0%
65 years and over	28.6%	23.4%

* Source: Based on U.S. Census 2015. DP05: American Community Survey, Demographic and Housing Estimates. 2011-2015 American Community Survey 5-Year Estimates.

Table 3. Highest Level of Education Completed: Survey Respondents and Florida Population

Education	Survey Respondents (N = 339) (%)	Florida Population (18 years and over) (%)*
Less than high school	7.4%	13.5%
High school graduate	31.9%	29.5%
Some college, associate's degree, bachelor's degree or higher	60.8%	57.0%
Total	**100.0%**	**100.0%**

* Source: Based on U.S. Census. 2015. S1501: Educational Attainment. 2011-2015 American Community Survey 5-Year Estimates.

Table 4. Household income before taxes in 2014: Survey Respondents and Florida Population

Income	**Survey Respondents (N = 269) (%)**	**Florida Population (%)***
Below $35,000	28.3%	37.3%
$35,000 to $49,999	19.7%	15.1%
$50,000 or more	52.0%	47.5%

* Source: Based on U.S. Census. 2014. S1901: Income in The Past 12 Months (In 2014 Inflation-Adjusted Dollars). 2010-2014 American Community Survey 5-Year Estimates

Trip Activities and Site Choice

One-third of the respondents (33%) came to the site primarily for canoeing, kayaking, or paddle boating; 28% came primarily for fishing from a pier or shore; and 20% came for fishing from a boat. The rest of the respondents participated in other non-extractive outdoor recreational activities (15%) or declined to answer the question (4%). The primary activities varied among the interview locations, with fishing (bank or boat) being the most popular activity at the Reservoir locations (Kirkpatrick Dam and Kenwood Landing), while canoeing and kayaking being the primary activity at the sites long the free-flowing river (Ray Wayside and Silver Spring) (Fig. 1). Eureka interview location serves as a border between free-flowing and impounded sections of the river, and the survey respondents were engaged in a diverse mix of activities at that site.

Respondents gave a variety of reasons for visiting particular sites (Fig. 3), with almost one-third indicating familiarity with the site (29%), and one-fourth indicating proximity to home (24%). Comments provided by respondents selected “Other” response option (32%) included site recommendations by others; site amenities (such as handicap accessibility, kid-friendly, parking, access to the Silver River and Springs, dog-friendly site, monkeys, etc.); the desire to explore something new; etc.

Figure 1. Responses regarding the primary outdoor recreational activity during the trip (%)

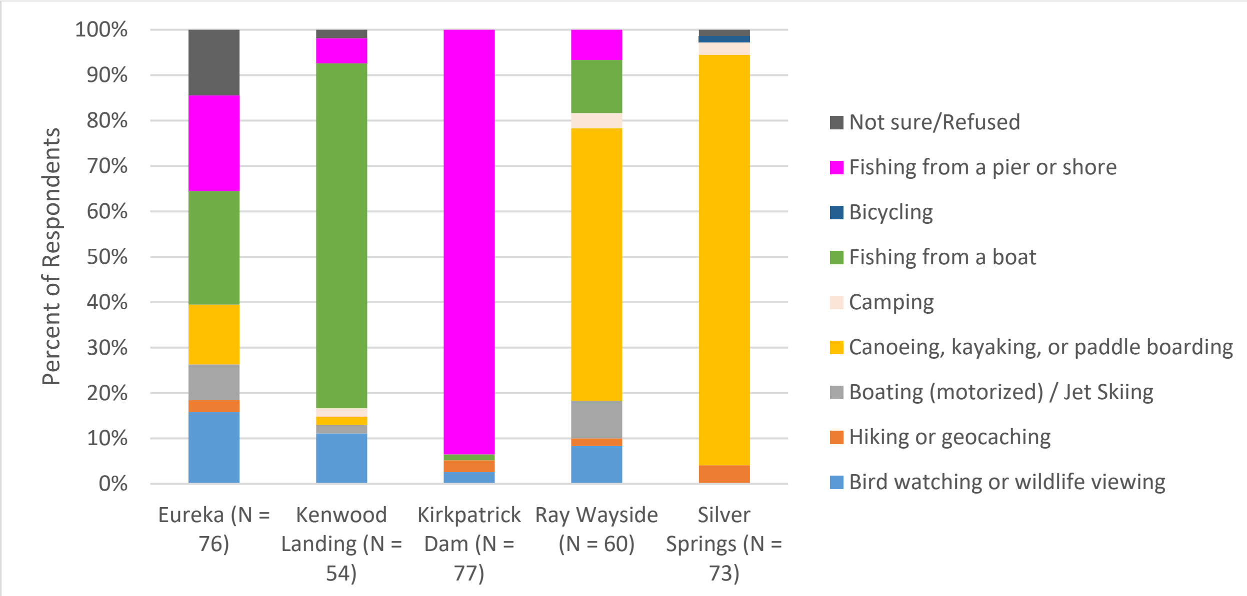
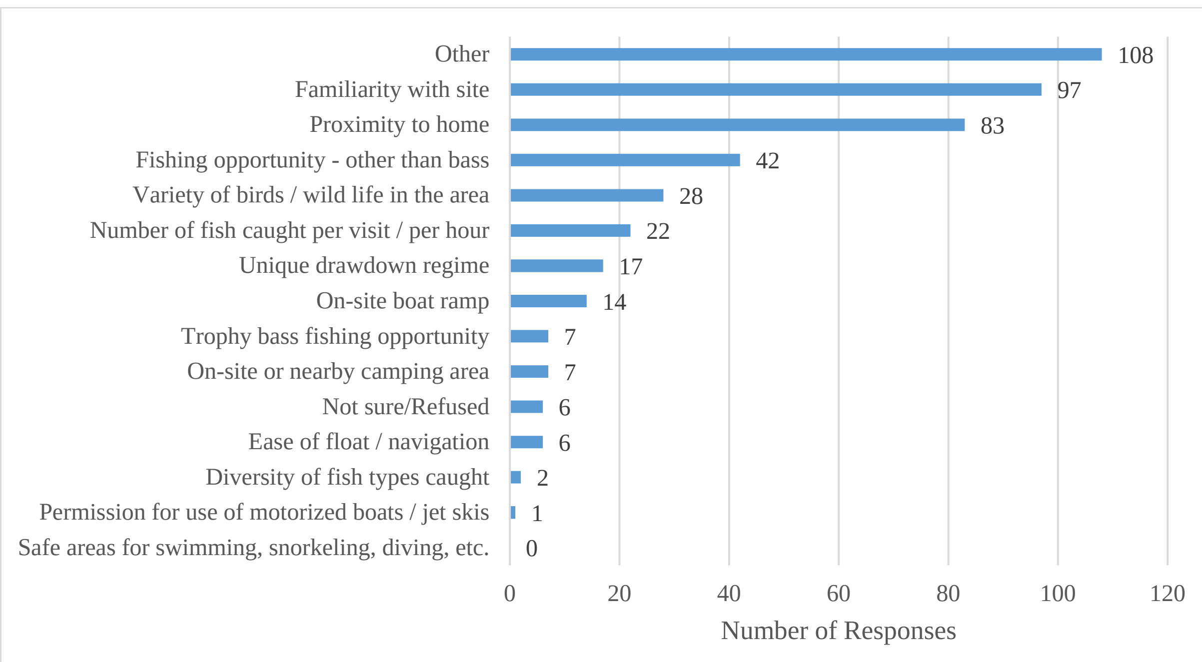


Figure 2. Number of responses for each answer choice of the question regarding reason for visiting a particular site



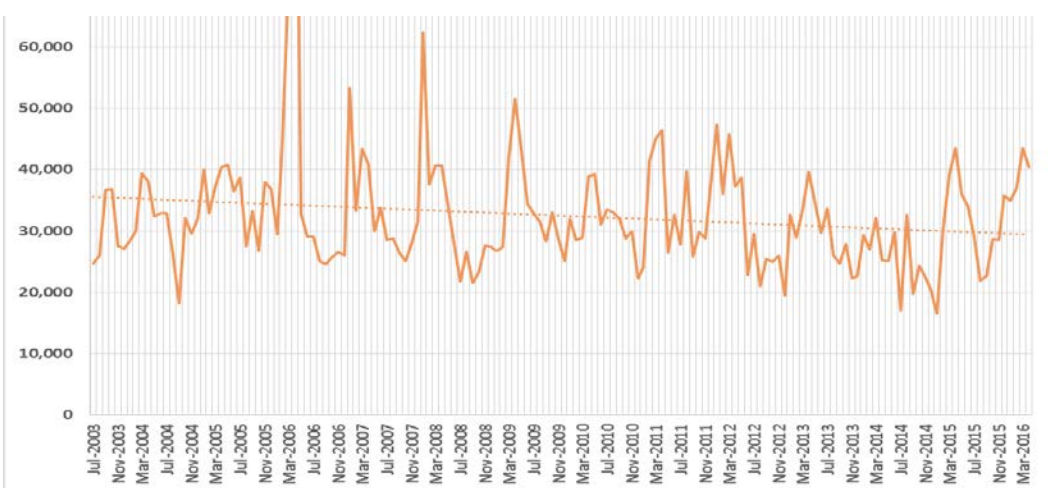
Visitor Economic Impact Analysis

This regional economic impacts of recreational visitors to the Ocklawaha River and Rodman Reservoir were estimated based the annual visitor volume, visitor spending and other information reported by survey respondents.

Information on monthly visitation to the Ocklawaha River and Rodman Reservoir was provided by the Florida Department of Environmental Protection and Marion County Parks and Recreation Department for 15 access points. These data are from automated vehicle counters installed at the access points, and are assumed to be representative of the number of visitor groups, rather than individuals. The data cover the period 2002 through 2015. A plot of monthly visitation during 2003-15 is shown in Figure 3. It is apparent that visitation is highly seasonal, with the largest numbers of visitors during the cool-season months of October through April.

The recreation sites were categorized as "River" or "Reservoir" locations, depending upon proximity to the Ocklawaha River or Rodman Reservoir. Average monthly visitation was calculated for each site to exclude missing values, then aggregated over the 12 months to estimate average annual visitation during 2013-15, as representative of current conditions. Average annual visitation for all sites was estimated at 368,307 groups, including 128,341 to river sites and 239,967, to reservoir sites.

Figure 3. Plot of monthly visitor groups to the Ocklawaha River and Rodman Reservoir, 2003-16



Note: scale truncated for outlier values. Data represent automatic vehicle counts. Source: Florida Department of Environmental Protection and Marion County Parks and Recreation Department.

Respondents for the on-site survey were asked to provide information on their home zip code, number of adults and children in the party, number of nights stayed in the area, types of recreational activities, primary activity, and trip expenditures in eleven different categories. The zip code information was used to calculate the driving distance to the recreation site on the shortest road pathway. Respondents who traveled 50 or miles to the site were considered “local” residents, while those travelling 50 or more miles were deemed “nonlocal” residents. Out of a total of 340 survey respondents, 140 (41.2%) were local residents and 200 (58.8%) were nonlocal, while 131 (38.5%) visited reservoir sites and 209 (61.5%) visited river sites (Table 7). Among respondents visiting reservoir sites, there were about equal numbers of local and nonlocal residents, whereas nearly twice as many respondents visiting river sites were nonlocal residents.

Table 5. Estimated average annual visitor groups by type of recreation site, 2013-15*

	Local	Nonlocal	Total All Respondents	Percent of Surveyed
Reservoir sites	98,810	141,157	239,967	38.5%
River sites	52,846	75,495	128,341	61.5%
Total all sites	151,656	216,651	368,307	
Percent of surveyed	41.2%	58.8%		

*Local visitors drove less than 50 miles from home zip code centroid to recreation site.
Visitor group data represent traffic counts.

The average party size was 2.6 (adults and children), however, larger groups were reported for camping (8.5) and motor boating (3.3). The average length of stay in the area was 2.5 days, and was significantly longer for hiking (8.5 days) and bird watching (4.6 days), as summarized in Table 9. Note that only one respondent reported bicycling as a primary activity, so this datum may not be reliable.

Table 6. Trip characteristics by local/nonlocal residents and survey location type

	Rodman Reservoir		Ocklawaha River		Total
	Local	Non-Local	Local	Non-Local	
Number respondents	63	68	77	132	340
Adults in party	114	173	182	325	794
Children in party	27	10	41	20	98
Average number of days on trip (all respondents)	1.1	3.1	1.0	3.7	2.5

Trip expenditures were reported by survey respondents either as a specific value or as a range of values ($0, $1-9, $10-24, $25-49, $50-99, $100-249, $250-499, $500+), for which the midpoint was taken as a point estimate.

Table 7. Visitor expenditures reported by type and primary activity

Expenditure Type	Fishing from pier or shore	Fishing from boat	Motor Boating	Canoeing, kayaking	Bird watching	Hiking	Camping	Bicycling	Other	Total
Average per person-day	*$24.8*	*$40.5*	*$26.8*	*$21.0*	*$13.5*	*$16.9*	*$9.8*	*$18.0*	*$59.3*	*$24.0*

The average expenditures per group-day were multiplied against the average annual number of visitor groups (2013-15) to estimate total annual visitor spending of $25.85 million (M), including $18.66 M for reservoir site visitors and $7.19 M for river site visitors.

The total expenditures were applied to the economic multipliers from a regional economic model to estimate total regional economic impacts. The model was created for the three local area counties of Putnam, Marion and Alachua using the IMPLAN economic impact analysis and social accounting software and 2014 county databases (Implan Group, LLC). The IMPLAN model provides multipliers that capture direct spending and employment (direct effects), industry supply chain activity (indirect effects) and household and government spending (induced effects). Expenditures by nonlocal visitors are considered as new final demand, subject to the full multiplier effects, while spending by local residents are treated as a transfer, subject only to the direct multiplier effect, as is common practice for economic contribution analysis. Each expenditure category was assigned to the appropriate IMPLAN industry sector. Note that visitor expenditures for purchases at retail gasoline stores, food and beverage stores, clothing stores and other miscellaneous stores are subject to a retail trade margin of 11 to 47 percent that represents the share of spending retained locally after deducting the cost of goods sold.

The total economic impacts of visitor spending for recreational use of the Ocklawaha River and Rodman Reservoir was estimated. Total impacts included employment of 384 fulltime and part-time jobs, value added or Gross Domestic Product (GDP) of $18.05 M, labor income of $11.10 M, and industry output (revenues) of $31.51 M (Table 8).

Table 8. Economic impacts of annual visitor spending for recreation on the Ocklawaha River and Rodman Reservoir

Site Type	Industry Output (Revenues)	Value Added (GDP)	Labor Income (Wages, Salaries, Benefits)	Employment (Fulltime, Part-time Jobs)
Rodman Reservoir	$23,327,553	$13,269,755	$8,000,068	279
Ocklawaha River	$8,181,903	$4,784,444	$3,095,806	105
Total	$31,509,456	$18,054,199	$11,095,874	384

Note that the results above are largely based on the visitation data collected by state agencies, and additional analysis should be conducted to minimize possible double-counting of the visitors. For example, as shown in Table 6, vehicle counters are installed at both public ramps and on Rodman Road East Side, potentially double-counting the same visitors.

Rodman Reservoir Management

There is an on-going debate about the future of the George Kirkpatrick Dam. Among the survey respondents, 46% stated that they were not at all informed about this issue, 20% were somewhat informed, and 30% were very informed (5% refused to answer). Note, however, that at Kenwood landing, 64.8% were very informed about the issue, while at Silver Spring (located relatively far from the Kirkpatrick Dam) only 2.7% were very informed about the issue.

For the question, “If it were up to you, would you choose to breach the dam or leave it as it is?”, 17% responded “breach it”, 54% responded “leave it as is”, and 29% were not sure or refused to answer. Interestingly, those respondents who stated that they are very informed about the controversy were most reluctant to share a definite opinion, complicating making any conclusion about public preferences for the management alternatives (Fig. 4).

The level of support for leaving the dam as is was especially high among those engaged in bird/wildlife viewing and fishing from a boat or pier / shore. In contrast, the support for breaching the dam was higher among those engaged in motorized boating, canoeing, kayaking, paddle boarding, and camping (Table 17).

Figure 4. Responses to the question "If it were up to you, would you choose to breach the dam or leave it as it is?", by the level of self-reported information on about the issue

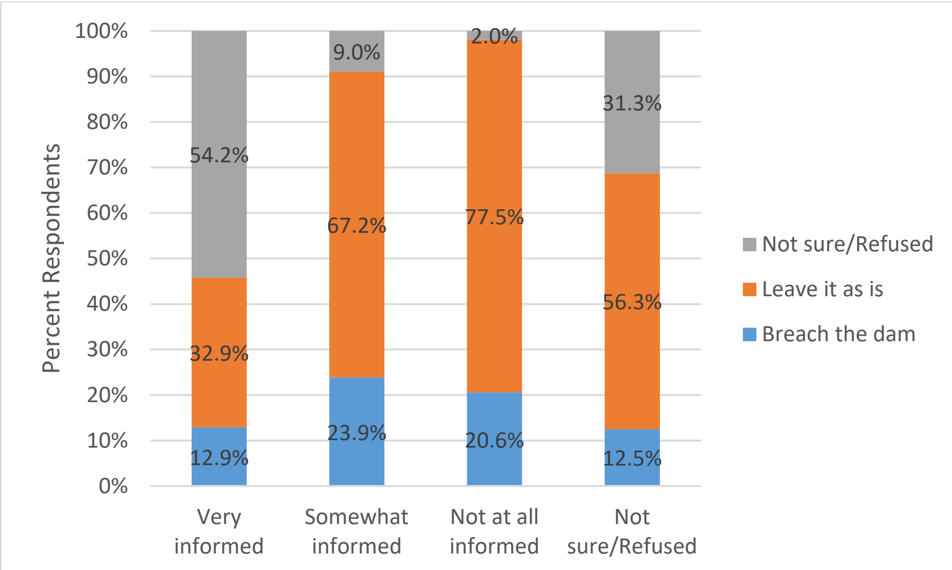


Table 9. Opinions about breaching the dam or leaving it as it is, by the primary activity during the trip

	Breach the dam	Leave it as is	Not sure/Refused
Bird watching or wildlife viewing	36.0%	52.0%	12.0%
Canoeing, kayaking, or paddle boarding	26.6%	16.8%	56.6%
Fishing from a boat	8.8%	85.3%	5.9%
Fishing from a pier or shore	4.2%	83.2%	12.6%

Among those who support breaching the dam, a majority thought that this would restore Silver Springs and the Silver River; and many also thought that breaching the dam would restore the lost / submerged springs and / or improve / protect aquatic ecosystems (Fig. 5). In turn, among those who preferred to keep the dam as is, approximately one-half thought this would improve / protect fishing at the site (Fig. 6).

Figure 5. Reasons given to support the opinion about breaching Kirkpatrick Dam

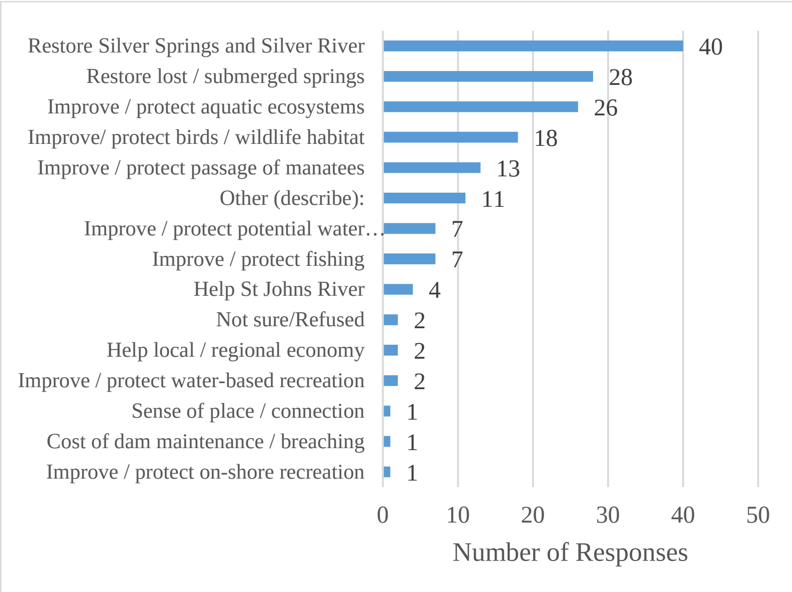
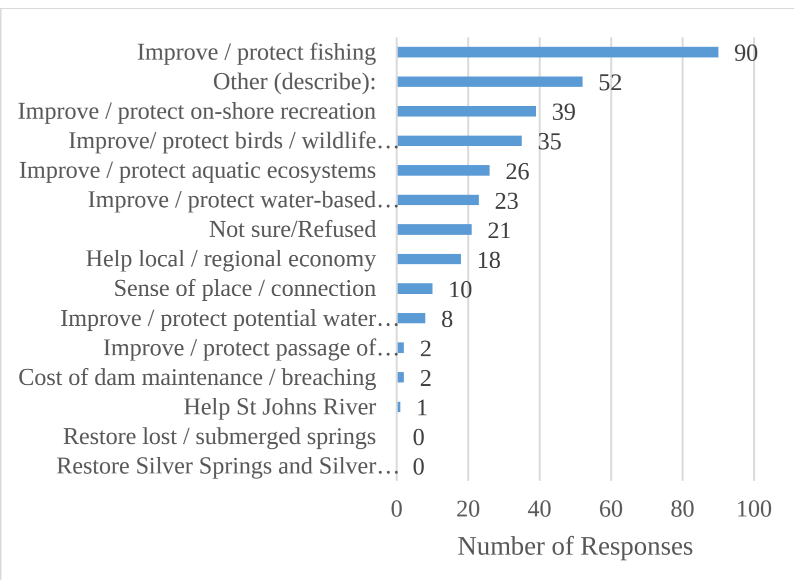


Figure 6. Reasons given to support the opinion about keeping Kirkpatrick Dam



The reasons given in support to a particular opinion regarding the dam management varied by the type of primary activity the visitors were engaged in. For example, among those supporting keeping the dam as is, bird and wildlife viewers were concerned about bird and wildlife habitat, while fishermen were most concerned about fishing opportunities that they perceived can be destroyed with the dam removal and reservoir drawdown. In turn, many of those engaged with canoeing and kayaking were supporting breaching the dam that they believed would improve Silver River and Silver Springs, restore submerged springs, and improve aquatic ecosystems.

Conclusion and Next Steps

This report represents an initial analysis of the survey responses provided by the visitors to the area. Next, information about the home zip codes of the respondents will be used to conduct an analysis of the distances traveled by the visitors that can help identify the total value of the recreational experiences for the visitors.

This report summarizes the responses for the first phase of the survey only. Our goal is to implement one more round of the survey to collect additional responses to better characterize the visitors who come to the region during the normal water management regime of the Rodman Reservoir.

The value of recreational experiences will be estimated using travel cost method (Freeman et al. 2014). This method treats the travel time and expenses as a “price” to access the recreational sites. The number of recreational trips is treated as “quantity” consumed at different prices, allowing to estimate demand function for recreation (i.e., the relationship between the price and the quantity of good purchased).

In this study, we focus only on the value of recreational uses of the river. There is a host of other values that are provided (or can be provided) by the river and the Spring (e.g., Randall 1987), such as the value of keeping these resources available for future generations; the value of providing habitat for fish and wildlife; inspiration, education, and cultural values; and the value of water storage or flood control. However, due to the limited funding available for the study, we focus on the recreational use only.

We also leave outside the scope of this study explicit consideration of the dam breaching / removal scenarios due to the significant uncertainty associated with these scenarios.[1] Instead, we compare the visitation to the region during two Rodman Reservoir management regimes: the drawdown and "normal" regime. However, we consider the visitation during the drawdown phase as a proxy for the potential visitation in the case of the Kirkpatrick Dam removal and the Ocklawaha River restoration.

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[1] For example, such impacts may or may not include downstream effects on the St. Johns River such as alternations of salinity levels in and pollution loading to the St. Johns River, and impacts on regional water supply.

References

American Rivers. 2008. American Rivers spreadsheet of all dams removed. Cited by the Society of Environmental Journalists. 2016. Nearly 800 Dams Already Removed Across U.S. The Society of Environmental Journalists, P.O. Box 2492 Jenkintown, PA 19046. http://www.sej.org/publications/tipsheet/nearly-800-dams-already-removed-across-us

Bass Master. 2016. The 10 Best Bass Lakes of 2016. Bass Master Magazine, http://www.bassmaster.com/best-bass-lakes/slideshow/10-best-bass-lakes-2016. Accessed January 17, 2017.

Bellmore R., J., Duda, J. J., Craig, L. S., Greene, S. L., Torgersen, C. E., Collins, M. J. and Vittum, K. 2016. Status and trends of dam removal research in the United States. WIREs Water. doi:10.1002/wat2.1164

Bellmore JR, Vittum KM, Duda JJ, Greene SL. USGS dam removal science database. US Geological Survey, 2015. http://doi.org/10.5066/F7K935KT. Accessed June 1, 2015.

Bi, X., Borisova, T., Larkin, S., & Longanecker,g J. (2015a). Economic Value of Recreation along the Freshwater Portion of the St. Johns River. In Hackney C.T. (ed.) St. Johns River Economic Study. Report submitted to the St. Johns River Water Management District under contract #27884. 38pp. http://floridaswater.com/stjohnsriver/pdfs/St._Johns_River_Economic_Study.pdf

Bi, X., Borisova, T., Larkin, S., & Longanecker, J. (2015b). An Estimate of the Current and Potential Value of Ecotourism in the St. Johns River. In Hackney C.T. (ed.) St. Johns River Economic Study. Report submitted to the St. Johns River Water Management District under contract #27884. 6pp. http://floridaswater.com/stjohnsriver/pdfs/St._Johns_River_Economic_Study.pdf

Bohlen C. and L.Y.Lewis. 2009. Examining the economic impacts of hydropower dams on property values using GIS. *Journal of Environmental Management*, 90, Supplement 3, p. S258–S269

Borisova, T., Collins, A., D'Souza, G., Bensong, M., Wolfe, M.L., & Benham, B. (2008). A benefit–cost analysis of total maximum daily load implementation. Journal of the American Water Resources Association, 44(4), 1009-1023.

Borisova, T., Hodges, A., & Stevens, T. (2015). Executive Summary of the Economic Contributions and Ecosystem Services of Springs in the Lower Suwannee and Santa Fe River Basins of North-Central Florida. IF/IFAS Extension, 4pp. http://edis.ifas.ufl.edu/fe958.

Brown P.H., Tullos, D., Tilt, B., Magee D., and A.T. Wolf. 2009. Modeling the costs and benefits of dam construction from a multidisciplinary perspective. Journal of Environmental Management 90, S303–S311.

Crane, K. 2016. What's best for Rodman Dam? Gainesville Sun, Dec 26, 2015, http://www.gainesville.com/news/20151226/whats-best-for-rodman-dam/1

Ehrlich, O., Bi, X., Borisova, T., & Larkin S. (2016, February 6 – 9). A Latent Class Analysis of Public Attitudes Towards Water Resources: Implications for Recreational Demand. Paper presented at the *2016 Southern Agricultural Economic Association Annual Meeting*, San Antonio, TX, 35pp. http://ageconsearch.umn.edu/handle/230058

Florida Defenders of the Environment (FDE). Date not Found. Ocklawaha River restoration. Fact Sheet. Florida Defenders of the Environment, Inc. 309 State Road 26, Melrose, Florida 32666.

Florida Department of Environmental Protection (FDEP). 2014. Fiscal Year 2013-2014: Florida State Park System – Economic Impact Assessment. FDEP, Tallahassee, FL.

Florida Department of Environmental Protection (FDEP). 2001. Basin Status Report: Ocklawaha. FDEP, Tallahassee, FL.

Freeman III, A. M., Herriges, J.A., and C. Kling. 2014. The Measurement of Environmental and Resource Values: Theory and Methods. 3rd edition. RFF Press, New York, NY, 459p.

Gilman, S. 2016. This Will Be the Biggest Dam-Removal Project in History. National Geographic, April 11, 2016, http://news.nationalgeographic.com/2016/04/160411-klamath-glen-canyon-dam-removal-video-anniversary/

Governor Rick Scott. 2016. Florida's award-winning state parks and trails continue record-breaking success. http://www.flgov.com/floridas-award-winning-state-parks-and-trails-continue-record-breaking-success-2/ .

Gowan C., Stephenson K., and L. Shabman. 2006. The role of ecosystem valuation in environmental decision making: Hydropower relicensing and dam removal on the Elwha River. Ecological Economics, 4(1), 508 – 523.

Graf W.L. 1999. Dam nation: A geographic census of American dams and their large-scale hydrologic impacts. Water Resources Research, 35(4): 1305-1311.

Hodges, A., Stevens, T., Rahmani, M., and R. Swett. 2013. Economic Analysis of Working Waterfronts in the United States. Draft Technical Report to U.S. Economic Development Administration for Sponsored Project Number 99-07-13873: Creating Community and Economic Development Tools for Preserving Working Waterfronts and Waterways. http://www.fred.ifas.ufl.edu/pdf/economic-impact-analysis/Economic-Analysis-Working-Waterfronts-Main.pdf

ICF Consulting. 2005. *A Summary of Existing Research on Low-Head Dam Removal Projects*. Report prepared for American Association of State Highway and Transportation Officials (AASHTO). ICF Consulting, 33 Hayden Ave., Lexington, MA 02421 USA. In association with Woodlot Alternatives, Inc.

Kareiva P. 2012. Dam Choices: Analysis for Multiple Needs. Proceedings of the National Academy of Sciences, April, 109(15), 5553–5554.

Kibler K.M., Tullos D.D., and G.M. Kondolf. Learning from Dam Removal Monitoring: Challenges to Selecting Experimental Design and Establishing Significance of Outcomes. River Research and Applications, 27, 967 – 975.

Kosnik L. 2010. Balancing Environmental Protection and Energy Production in the Federal Hydropower Licensing Process. Land Economics, 86(3), 444-466.

Kotchen M.J., Moore M.R., Lupi F., and Rutherford E.S. 2006. Environmental Constraints on Hydropower: An Ex Post Benefit-Cost Analysis of Dam Relicensing in Michigan. Land Economics, August 2006 . 82 (3): 384–403.

Lavigne, P. 2005. *Dam(n) How Times Have Changed...*, 29 Wm. & Mary Envtl. L. & Pol'y Rev., 451, http://scholarship.law.wm.edu/wmelpr/vol29/iss2/5

Lewis, L. Y., C. Bohlen, and S. Wilson. 2008. Dams, Dam Removal, and River Restoration: A Hedonic Property Value Analysis. *Contemporary Economic Policy*, 26, 2008, 175–86.

Lewis, R. R. 2015. Management and restoration of the fish populations of Silver Springs and the Middle and Lower Ocklawaha River, Florida, USA. A report prepared for the Putnam County Environmental Council. Revised Version 1. 30 p + append.

Loomis J. 1996. Measuring the Economic Benefits of Removing Dams and Restoring the Elwha River: Results of a Contingent Valuation Survey. Water Resources Research, 32(2), 441 – 447.

Loomis J. 2002. Quantifying recreation use values from removing dams and restoring free-flowing rivers: A contingent behavior travel cost demand model for the Lower Snake River. Water Resources Research, 38(6), 1066 – 1073.

Loomis, J., Kent, P., Strange L., Fausch, K. and A. Covich. 2000. Measuring the total economic value of restoring ecosystem services in an impaired river basin: results from a contingent valuation survey. *Ecological Economics*. 33(1), 103-117.

Mattmann M., Logar I., and R. Brouwer. 2016. Hydropower externalities: A meta-analysis. Energy Economics, 57, 66- 77.

McKean, J., Johnson, D., Taylor, R.G., and Johnson, R.L. 2005. Willingness to Pay for Non Angler Recreation at the Lower Snake River Reservoirs. Journal of Leisure Research, 37(2), 178 – 194.

McKean, J., Johnson, D., Taylor, R.G. 2010. Willingness-to-pay for steelhead trout fishing: Implications of two-step consumer decisions with short-run endowments. Water Resources Research, 46(9).

McKean, J., Johnson, D., Taylor, R.G. 2012. Three approaches to time valuation in recreation demand: A study of the Snake River recreation area in eastern Washington. Journal of Environmental Management. 112, 321-329.

Moore D., Dore J., and D. Gyawali. 2010. The World Comission on Dams +10: Revisiting the Large Dam Controversy. Water Alternatives, 3(2), 3 – 13.

Mulkey D. & A. Hodges. 2000. Using Implan to Assess Local Economic Impacts. EDIS #FE168. Gainesville, FL: UF/IFAS Extension. https://edis.ifas.ufl.edu/fe168.

Nijhuis M. 2015. Movement to Take Down Thousands of Dams Goes Mainstream. National Geographic, January 29, 2015. http://news.nationalgeographic.com/news/2015/01/150127-white-clay-creek-dam-removal-river-water-environment/

Nilsson C., Reidy C.A., Dynesius M., and C. Revenga. 2005. Fragmentation and Flow Regulation of the World's Large River Systems. Science, New Series, 308(5720): 405-408.

Noll S. and D. Tegeder. 2015. Ditch of Dreams: The Cross Florida Barge Canal and the Struggle for Florida’s Future. University of Florida Press, Gainesville, FL, 416p.

O’Hanley J. 2011. Open Rivers: Barrier Removal and the restoration of free-flowing rivers. Journal of Environmental Management. 92, 3112 – 3120.

Provencher B, Sarakinos, H., and T. Meyer. 2008. Does Small Dam Removal Affect Local Property Values? An Empirical Analysis. *Contemporary Economic Policy*, 26 (2), 187–197

Randall, A. 1987. Total Economic Value as a Basis for Policy. Transactions of the American Fisheries Society, 116(3): 325-335.

Richter, B.D.; Postel, S.; Revenga, C.; Scudder, T.; Lehner, B.; Churchill, A. and Chow, M. 2010. Lost in development’s shadow: The downstream human consequences of dams. Water Alternatives 3(2): 14-42

Robbins, Jesse Lance and Lynne Y. Lewis, 2008. Demolish It and They Will Come: Estimating the Economic Impacts of Restoring a Recreational Fishery. Journal of the American Water Resources Association (JAWRA)44(6):1488-1499. DOI: 10.1111⁄j.1752-1688.2008.00253.x

Smith M.G. 2006. Dam Removal: A Taxonomy with Implications for Economic Analysis. *Journal of Contemporary Water Research & Education*, 134: 34-38.

Shuman, J.R. 1995. Environmental Considerations for Assessing Dam Removal Alternatives for River Restoration. *Regulated Rivers: Research & Management*, 11, 249 – 261.

Stanley E.H. and M.W. Doyle. 2005. Trading off: the ecological effects of dam removal. *Front Ecol Environ* 2003; 1(1): 15–22

Taylor, E. 2012. 'Freeing' Ocklawaha wouldn't be free or beneficial. Jul 22, 2012, http://www.ocala.com/news/20120722/freeing-ocklawaha-wouldnt-be-free-or-beneficial

Tullos D., Tilt B., and C.R. Liermann. 2009. Introduction to the special issue: Understanding and linking the biophysical, socioeconomic and geopolitical effects of dams. Journal of Environmental Management 90: S203–S207.

U.S. Army Corps of Engineers (USACE). 2016. CorpsMap. National Inventory of Dams. http://nid.usace.army.mil/cm_apex/f?p=838:5:0::NO (Accessed on September 7, 2016).

U.S. Census. 2015. DP05: American Community Survey, Demographic And Housing Estimates. 2011-2015 American Community Survey 5-Year Estimates. U.S. Census Bureau, https://factfinder.census.gov/faces/tableservices/jsf/pages/productview.xhtml?src=CF

U.S. Department of Agriculture Forest Service (USDA FS). 2001. Draft Environmental Impact Statement for the Ocklawaha River Restoration Project. Management Bulletin R8-MB 88. U.S. Department of Agriculture, Forest Service Southern Region.

U.S. Environmental Protection Agency (USEPA). 2016. Frequently Asked Questions on Removal of Obsolete Dams. U.S. Environmental Protection Agency, Office of Water, EPA-840-F-16-001. https://www.epa.gov/sites/production/files/2016-12/documents/2016_december_2_clean_final_dam_removal_faqs_0.pdf

Whitelaw E. and E. MacMullan. 2002. A Framework for Estimating the Costs and Benefits of Dam Removal. BioScience, 52(8), 724 – 730.

Winemiller K.O., McIntyre P.B., Castello L., Fluet-Chouinard E., Giarrizzo T., Nam S., Baird I.G., Darwall W., Lujan N.K., Harrison I., Stiassny M.L., et al.. 2016. Balancing hydropower and biodiversity in the Amazon, Congo, and Mekong. Science 351:128–129.

World Commission on Dams (WCD). 2000. Dams and development: a new framework for decisions-making. London: Earthscan Publications.

Zarfl, C., Lumsdon, A.E., Berlekamp, J., Tydecks L., and K. Tockner. 2015. A global boom in hydropower dam construction. Aquat Sci 77: 161 - 170.

Ziv G, Baran E, Nam S, Rodríguez-Iturbe I, Levin SA (2012) Trading-off fish biodiversity, food security, and hydropower in the Mekong River Basin. Proc Natl Acad Sci USA 109:5609–5614.