Ocklawaha River Restoration: Science and Economics Report

ACKNOWLEDGEMENTS

The Ocklawaha River Restoration: Science and Economics Report was developed by a large team of expert contributors. We would like to thank the report work group led by A. Quinton White Jr., Ph.D. (Jacksonville University, retired) and members Alan Hodges, Ph.D. (University of Florida), Stephen Walsh, Ph.D. (U.S. Geological Survey, retired), Rob Mattson, M.S. (St. Johns River Water Management District, retired), John Hendrickson, M.S. (St. Johns River Water Management District, retired), Tom Hoctor, Ph.D. (University of Florida), Reed Noss, Ph.D. (Conservation Science Inc.), and Cameron Jaggard (The Pew Charitable Trusts). Mike Wissner (The Pew Charitable Trusts), Elizabeth Thompson (University of Florida), Michael O'Brien, Ph.D. (University of Florida), Susan Carr (Alachua Conservation Trust), and Willy The Losen (Putnam Land Conservancy) provided mapping support in the development of the report. Independent, expert peer review was provided by Jason M. Evans, Ph.D. (Stetson University), Seth Wenger, Ph.D. (University of Georgia), and Christopher de Bodisco, Ph.D. (High Point University). Financial support for the report was provided by The Pew Charitable Trusts.

COVER PHOTOGRAPHS

A tour boat carries wildlife enthusiasts on the Ocklawaha River. Restoration could provide new and expanded river and springs-based recreational opportunities. Credit: Doug Engle

A paddler explores Cannon Spring during a Rodman Reservoir drawdown event, where water levels are lowered to control invasive aquatic vegetation. Cannon Spring is one of approximately 20 'lost springs' currently submerged by the Rodman Reservoir. Credit: John Moran

Florida bass are a target species for local anglers. Fishing opportunities for Florida bass would endure post-restoration and, overall, restoration could provide more diverse and abundant fishing opportunities for a range of fishes. Credit: Bill Hawthorne

TABLE OF CONTENTS

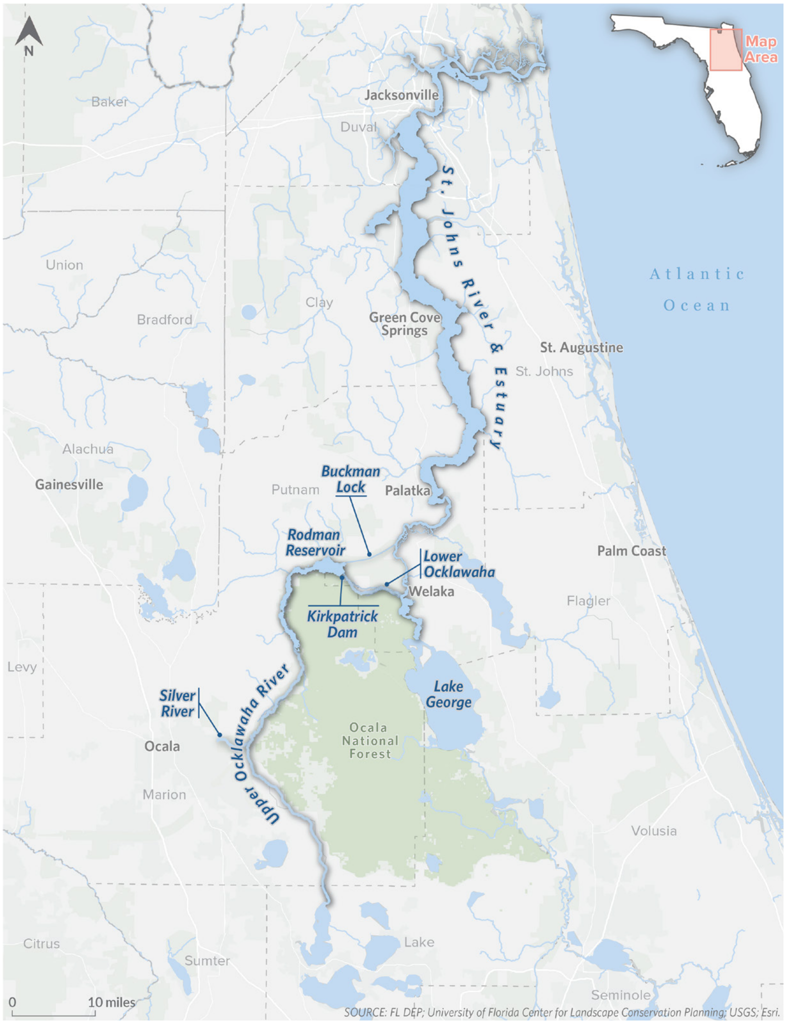


Figure 1. The Ocklawaha, the Silver, and the Lower St. Johns form a three-part river system that reaches over 217 miles from Lake Apopka to the Atlantic Ocean.

The Silver and Ocklawaha Rivers, and Lower St. Johns River Basin support valuable commercial, recreational and subsistence fisheries. Restoration is anticipated to provide an overall net-benefit to these fisheries. Credit: Doug Engle

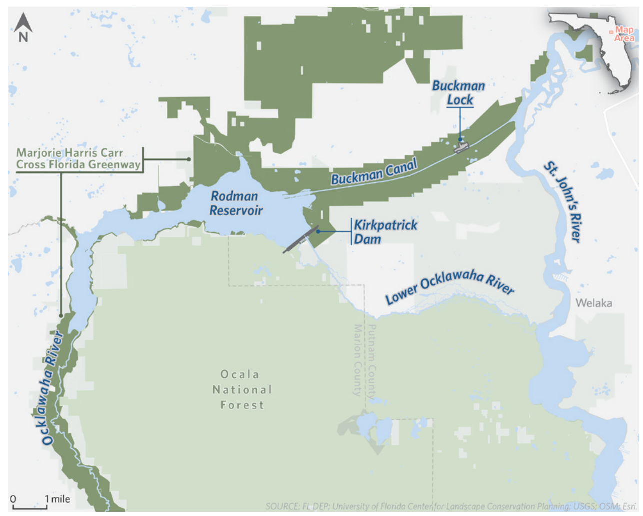


Figure 2. The Kirkpatrick Dam is a 22-foot-high, 6,800-foot-long earthen structure with four gates and a concrete spillway (Shuman 1995).

EXECUTIVE SUMMARY

The Ocklawaha River, with contributions from the first-magnitude Silver Springs and Silver River, is the primary tributary to the largest river in Florida—the St. Johns River (DEP 2018a) (Fig. 1). Over 60 years ago the Army Corps of Engineers' Cross-Florida Barge Canal project constructed what is now known as the Kirkpatrick Dam (Noll and Tegeder 2009). The project was halted by President Richard M. Nixon in 1971, and since that time stakeholders and state decision-makers alike have debated the future of the Ocklawaha River, the dam, and associated Rodman Reservoir (Noll and Tegeder 2009). Recently, local and state leaders have recognized the lack of an up-to-date, comprehensive assessment of the science and economics of maintaining the dam versus breaching it and restoring the Ocklawaha River as a primary impediment to decision-making.

This report seeks to address this need. The report provides a thorough review of existing literature, as well as new geospatial analysis, cost estimates and analysis of the costs and benefits of restoration. Specifically, the report examines the proposal to breach the Kirkpatrick Dam and restore the Ocklawaha River in the context of economic, recreation, conservation, and public safety considerations for which existing scientific research and new analysis is robust. As Florida lawmakers consider this issue, the report aims to provide relevant information that can support their efforts to determine the best course of action for the future of the dam, associated river systems, and communities.

THE ECONOMICS OF OCKLAWAHA RIVER RESTORATION

The primary components of Ocklawaha River restoration include breaching a section of the 2,000-foot Kirkpatrick Dam, closing the Buckman Lock, plugging canal channels intersecting with major creeks, some revegetation for earth stabilization, and returning the water level to its natural state (USFS 2001) (Fig. 2). Estimated restoration costs total $70.03 million over a period of four years, with initial Year 1 expenses of $21.7 million, then costs decreasing from $23.4 million in Year 2 to $9.7 million in Year 4 (RES 2024). Improvements to support continued water access and increase visitation post-restoration are estimated at $25 million for discussion purposes. The total restoration and recreational improvement costs are $95.03 million. Additional private costs associated with restoration include reduced property value and water access for approximately 16 individual private landowners abutting the Rodman Reservoir, and reduced or altered fishing opportunities for recreational, charter, and subsistence fishermen resulting from loss of the reservoir and spillway fisheries. Developing improved boating and shoreline access projects in consultation with local stakeholders, governments, state agencies and others can assist in addressing these community needs.

Short-Term Economic Impacts

Restoration activities and development of associated recreational access improvements are projected to generate positive economic impacts for communities, including those of Putnam, Marion, and Alachua counties. These economic impacts are estimated to create the equivalent of 859 jobs for one year (i.e., job-years), $44.4 million in labor income, $78.3 million value added (GDP), $136.1 million in industry output or business sales revenue, $2.33 million in state tax, and $1.69 million in county and subcounty district taxes in 2024 dollars. The projected output impact (business revenue) of $136.1 million is 1.43 times the total restoration and example recreational improvement spending, implying an overall multiplier effect of 1.44 (Appendix B).

In contrast, dam operation costs average $442,817 per year (2024 dollars) (Cross-

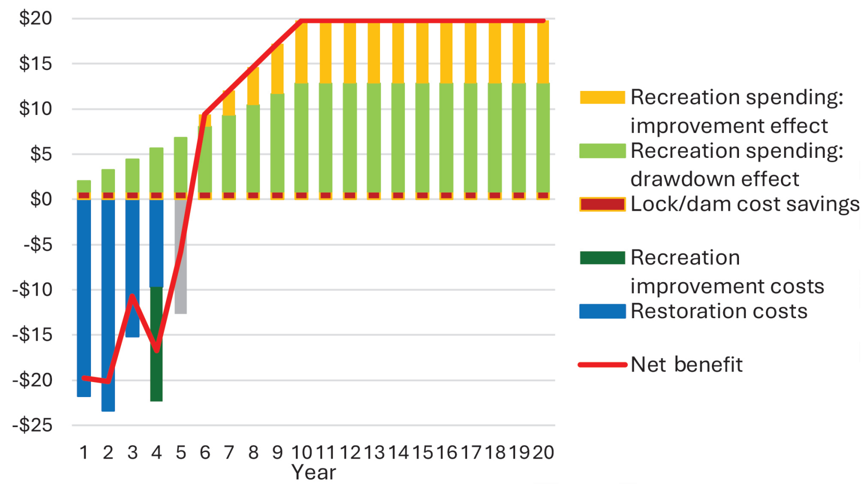


Figure 3. Graph of annual costs and benefits for Ocklawaha River restoration and example recreational improvements over 20 years.

Figure 4. The Ocklawaha River is a critical link in the Florida Wildlife Corridor and the Florida Ecological Greenways Network.

Florida Greenway manager's office). In addition, the dam and associated structures face a backlog of $4 million in deferred repairs and maintenance. The total avoided cost benefit for elimination of operations and maintenance of the lock and dam complex resulting from restoration is estimated to average $842,000 per year.

Near-Term Investment, High Long-Term Return

The net economic benefits of Ocklawaha River restoration are negative during the first five years, reflecting the large upfront restoration and example recreational improvement costs during this period; then net benefits rise to $19.80 million starting in Year 10 (Fig. 3). Total cumulative net benefits over 20 years are estimated at $198.23 million. The benefit-cost ratio for the project is 2.09, meaning every dollar of investment generates $2.09 in net benefits. Applying an annual discount factor of 3% to give benefits and costs in net present value (NPV) terms reduces the benefit-cost ratio to 1.32 (Appendix B).

Recreation and Conservation Implications

Review and analysis of available scientific research identified fish and fishing, the Florida Wildlife Corridor, freshwater springs and the Lower St. Johns River and estuary as primary topics for examination given the abundance of scientific information available and their importance to local and state priorities.

Fish and Fishing

The 9,500-acre Rodman Reservoir and the associated dam spillway tailwaters currently support popular recreational and subsistence fisheries, including Florida bass and black crappie (DEP 2024a). Breaching the Kirkpatrick Dam would eliminate the reservoir and flow through the spillway that supports these existing fisheries. Recreational enhancements, such as improved Ocklawaha and Lower St. Johns River access for boat and shore-based anglers, could offset some of these impacts to fishermen. Importantly, viable fisheries for these species would endure in the restored Ocklawaha River and, based on other dam removals, fish species diversity and abundance throughout the Ocklawaha River upstream of Kirkpatrick Dam would likely increase following restoration of the river (Bellmore et al. 2019). Fish species that are important to commercial and recreational fisheries, such as American eel, striped bass, striped mullet, and white and channel catfish, could be among the beneficiaries (Knight et al. 2021). More broadly, restored freshwater flow from the Ocklawaha River could benefit fisheries of the Lower St. Johns River Basin by improving conditions for estuarine finfish and shellfish, such as red drum, spotted trout, Atlantic croaker, flounder, blue crab, and shrimp (Pinto et. al. 2024).

Florida Wildlife Corridor

The Ocklawaha River is a major riverine pathway in the Florida Wildlife Corridor's over the 100-mile-long Ocala-to-Osceola corridor (O2O)—one of the state's highest-priority habitat conservation areas, as demonstrated by significant state investments in land conservation (DEP 2024b) (Fig. 4). Rodman

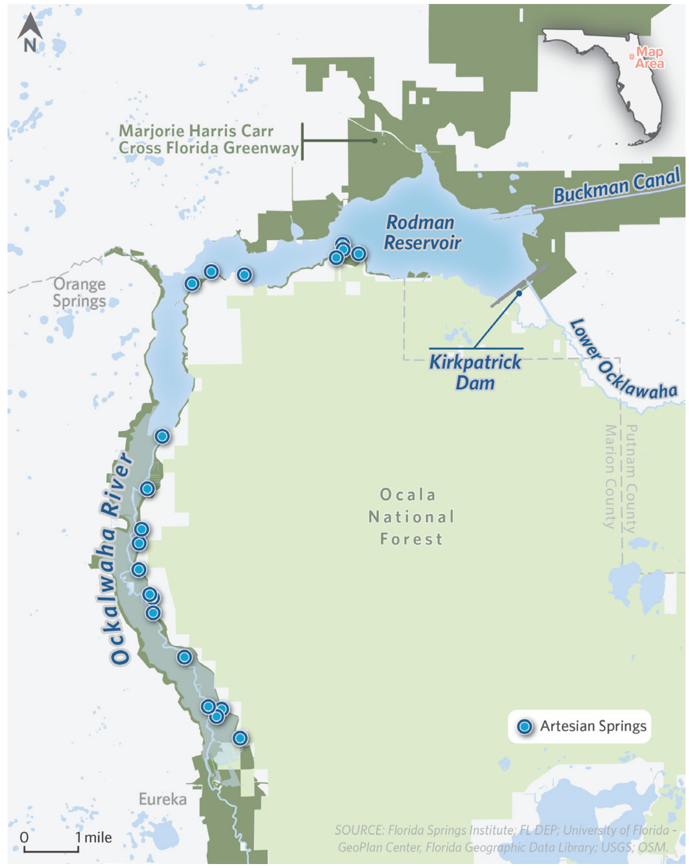


Figure 5. The Rodman Reservoir reduces or eliminates water flow from 20 freshwater springs that could contribute additional flow, recreational opportunities, and benefits to fish and wildlife if the Ocklawaha River were restored.

Reservoir sits in the middle of the O2O corridor and, as a large expanse of open water, invasive aquatic plants, and herbaceous wetlands, is likely to impede movement of wildlife. Restoring the Ocklawaha River would remove this obstacle and enhance connectivity for wide-ranging and landscape-dependent species, including the federally listed endangered Florida panther and Florida black bear, as well as enhanced access to food and warm-water wintering habitat for threatened Florida manatee (USFWS 2008; FWC 2024a; Federal Register 2024; Valade 2020).

Silver Springs and Springs of the Ocklawaha River

Silver Springs is one of the largest artesian springs in the world, the largest springs group in Florida by magnitude of flow, and one of the state's oldest tourist attractions (DEP 2014. DEP 2015). However, Silver Springs faces significant challenges, including increased nutrient pollution, algae growth, and declines in historically abundant fish species (Odum 1957; Knight 1980; Munch et al. 2006). Restoring the Ocklawaha River could increase freshwater flow, bring back historic fish communities, and enhance access for other species that supported spring and broader river ecosystem health (Hitt et al. 2012; Jordan 1994a, 1994b; Sutherland et al., 2017). Furthermore, the Rodman Reservoir reduces or eliminates the flow of approximately 20 springs that could support public use and tourism (Hendrickson et al. 2015; SJRWMD 2017) (Fig. 5).

Lower St. Johns River and Estuary

The Kirkpatrick Dam and Rodman Reservoir present water quality challenges for the Lower St. Johns River and estuary. During the refill stage following Rodman Reservoir drawdowns, the Ocklawaha's reduced flow leads to significant upstream encroachment of saltwater into the St. Johns River, harming submerged aquatic vegetation that supports fish, manatees, and broader river health (Hendrickson et al. 2015; Dobberfuhl et al. 2012). The large, shallow reservoir also evaporates significant amounts of water to the atmosphere and suppresses or reverses artesian springs of the Ocklawaha River (Hendrickson et al. 2015). Data suggests the reservoir's capacity to absorb phosphorus has declined, potentially increasing phosphorus pollution in the Lower Ocklawaha and St. Johns River during drawdowns (Hendrickson et al. 2015). However, the reservoir retains silica—a mineral that can reduce harmful algal blooms by promoting healthy freshwater food webs—and hinders dispersal of eelgrass, which provides important feeding and nursery habitat for species such as Florida bass, from the Silver and Ocklawaha Rivers to the Lower St. Johns River (Tillmans 2008; Humborg et al. 1997; Ittekkot et al. 2000; Jarvis and Moore 2008). Restoration is anticipated to increase flow from the Ocklawaha River, thereby reducing saltwater intrusion, improving water quality and freshwater food webs, and contributing to eelgrass growth and dispersal in the Lower St. Johns River.

Public Safety

The U.S. Army Corps of Engineers identifies the Kirkpatrick Dam and Reservoir as a potential high hazard to the downstream area in the event of "failure or mis-operation of the dam or facilities (USACOE 2023)." The approximately 11,000-acre inundation area (URS 2007) (Fig. 6) contains approximately 538 properties that, if flooded, could result in loss of life and represent a total loss of $57.4 million (Spontak 2020). Partial restoration would eliminate structural flood hazards associated with dam failure, as well as provide nonstructural flood protection in the form of a 7,500-acre restored floodplain forest that could absorb floodwaters (DEP 2018a).

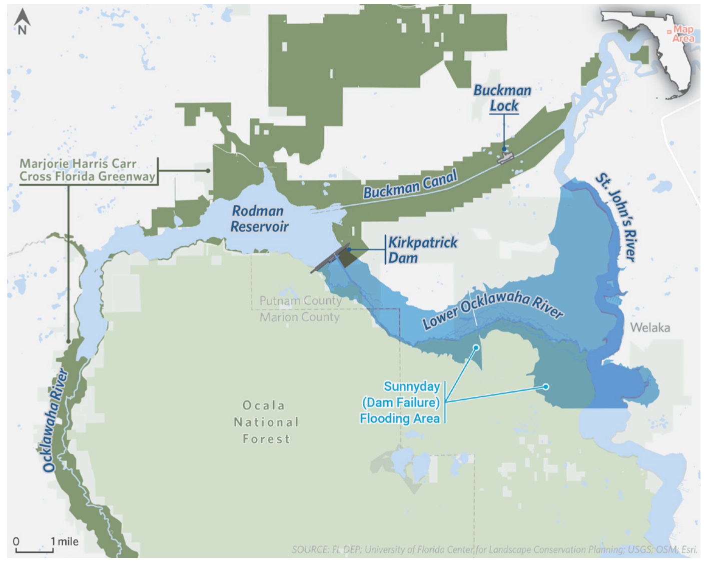


Figure 6. The inundation area at risk in the event of Kirkpatrick Dam failure.

CONCLUSION

Existing literature, new geospatial analysis, cost estimates and analysis of restoration indicate that restoration could provide overall net public safety, economic, and conservation benefits over continued maintenance and operation of the Kirkpatrick Dam and Rodman Reservoir. Breaching the dam would benefit public safety by eliminating flood hazards associated with the high-hazard dam and providing non-structural flood protection in the form of a 7,500-acre restored floodplain forest. Socioeconomic impacts are anticipated for a limited number of local stakeholders, such as alteration of fishing opportunities, and restoration would require substantial upfront investment, however restoration activities and recreational access improvements are projected to create the equivalent of 859 jobs for one year (i.e., job-years), $44.4 million in labor income, $78.3 million value added (GDP), $136.1 million in industry output or business sales revenue, $2.33 million in state tax, and $1.69 million in county and subcounty district taxes in 2024 dollars. Long-term, restoration would generate cumulative net benefits over 20 years estimated at $198.23 million, where every dollar of investment generates $2.09 in net benefits.

Restoring the river's natural flow would reconnect this important aquatic and terrestrial pathway bolstering state investments in the O2O Corridor and promoting recovery of imperiled species, such as the Florida panther and manatee. The diversity and abundance of native fish species could increase, including species popular among anglers and important to the health of Silver Springs and the Silver, Ocklawaha and St. Johns rivers and estuary. The St. Johns River – Florida's longest river - is anticipated to received increased, unimpeded freshwater flow from the Ocklawaha River that could reduce saltwater intrusion and improve water quality, freshwater food webs and habitat.

A comprehensive approach that enables river restoration, as well as addresses community needs by improving recreational access could maximize the project's economic and environmental benefits. The report provides examples of river-based recreation projects that, if included in restoration, could promote public use of the restored river and associated economic benefits. Florida lawmakers are uniquely positioned to craft a broader strategy that would advance restoration, improve river access and recreation opportunities, and support job creation and economic diversification for local communities and the larger region.


View of the Lower Ocklawaha River adjacent the Kirkpatrick Dam. Credit: Cam Jaggard

INTRODUCTION

This report provides a comprehensive review of existing literature, as well as new geospatial analysis, cost estimates, and economic analysis of the costs and benefits of restoration. The narrative includes the historical perspective of the Cross Florda Barge Canal project and overview of the riverway that it impacted, as well as the proposed Ocklawaha River restoration project that could address historic and ongoing impacts. Environmental and economic implications of restoration are examined, as are the projected costs of restoration vs. continued operation of the Rodman Reservoir, Kirkpatrick Dam, and associated infrastructure in current 2024 dollars. Finally, potential stakeholder impacts and opportunities to offset these impacts are discussed.

Aerial view overlooking construction of the Cross Florida Barge Canal at the St. Johns Lock, which is now known as the Buckman Lock.

Credit: Florida Memory.

HISTORICAL PERSPECTIVE

THE CROSS FLORIDA BARGE CANAL

As detailed in *Ditch of Dreams: The Cross Florida Barge Canal and the Struggle for Florida's Future* (Noll and Tegeder 2009), throughout much of the 19th and 20th centuries, water transportation advocates in Florida consistently lobbied the state and federal governments to connect the Atlantic Ocean to the Gulf of Mexico via a cross-state canal, a project intended to place the state at the center of American commerce and prosperity. Started in 1935 as part of President Franklin D. Roosevelt's New Deal, the ship canal was designed to be a 40-foot-deep gash across the state, so that oceangoing vessels could travel from the Gulf of Mexico to the Atlantic Ocean without having to go around the Florida Peninsula. Designed to be constructed on a path mapped out by the Army Corps of Engineers, the canal was to go from Yankeetown on the Gulf Coast to Jacksonville on the Atlantic, using the existing courses of the Withlacoochee, Ocklawaha, and St. Johns rivers. It was to be the largest public works project in Florida history. It was stopped in 1936 when Congress denied further fiscal authorization because of environmental concerns over potential saltwater intrusion into the Floridian aquifer. These concerns were raised mostly by Florida agricultural interests. Other opposition centered on the exorbitant expense of the project, with no firm accounting for how much it would cost.

Aerial view of the Lower Ocklawaha River and the Kirkpatrick Dam. Credit: Doug Engle

Aerial view of the Kirkpatrick Dam spillway and invasive aquatic plants. Credit: Reinier Munguia

Supporters of the canal would not be deterred, however. They met with engineers from the Army Corps to reformat the ship canal into a barge canal, which would be only 12 feet deep and use locks and dams to traverse the state. This new configuration, along the same route as the ship canal, was designed to ostensibly not damage the aquifer and thus allay the fears of Florida's farm interests. These canal boosters also tied the new iteration of the canal to issues of national defense, maintaining the canal would provide a protected lane for America's vital shipping concerns. When a German U-boat sank an oil tanker off the coast of Jacksonville Beach in April 1942, Congress acted to authorize the building of the Cross Florida Barge Canal along the same route as the now abandoned, partially completed ship canal. However, Congress failed to authorize funding for the canal's construction. Throughout the 1940s and 1950s, boosters continued to push state and federal officials to allocate funding for the canal. Finally, in late 1963, Congress approved the initial funding for building the canal, and in February 1964, President Lyndon B. Johnson came to Palatka for a groundbreaking ceremony. Rodman Reservoir was originally created as the eastern entry pool for the Cross Florida Barge Canal project. The reservoir was first filled in 1968, flooding 24 miles of the lower Ocklawaha Valley from County Road 316 at Eureka to Riverside Landing, the location of the Kirkpatrick Dam.

HALTING THE CROSS FLORIDA BARGE CANAL

Citizen activists led by Marjorie Harris Carr, Bill Partington, and David Anthony organized opposition to canal construction on the grounds it would destroy the natural beauty of the Ocklawaha River. By 1969, opponents sued the Corps to stop the canal construction. Carr and her allies focused on the deleterious effects of canal construction on the river and attendant ecosystem.

In January 1971, the U.S. District Court in Washington, D.C., and President Richard M. Nixon both ordered canal construction to be halted. With about one-third of construction completed, the canal was now a dead issue, never to be finished. Following the decision, serious questions remained as to the disposition of the lands designated for future canal completion, as well as what to do with completed canal structures, especially Rodman Dam and its attendant Rodman Reservoir on the Ocklawaha River.

In 1991, federal de-authorization of the Cross Florida Barge Canal Project resulted in the transfer of canal lands to Florida for use as a linear cross-state park known today as the Marjorie Harris Carr Cross Florida Greenway (CFG). This was a remarkable conservation victory, as the potential industrial waterway has been turned into a 110-mile swath of land and water to be used for recreational activities. An ad hoc Canal Lands Advisory Committee (CLAC) was formed to provide recommendations to the governor and cabinet on the disposition of the barge canal lands and structures. After deliberating on the recommendations of the CLAC, the 1993 Legislature passed Chapter 92-213, Laws of Florida, which directed the Department of Natural Resources (now the Florida Department of Environmental Protection [DEP]) to "study the efficacy, both environmental and economic, of complete restoration of the Ocklawaha River, partial restoration of the river, total retention of Rodman Reservoir, and partial retention of the reservoir." Funds were provided for the St. Johns River Water Management District (SJRWMD) to undertake the study of four alternatives for restoration. Ultimately, the DEP, U.S. Forest Service (USFS), and Florida Legislature favored partial restoration as the most environmentally sound and cost-effective alternative to restore river hydrology and floodplain function (USFS 2001; DEP 1997).

Decades of debate over whether to restore the Ocklawaha River may now be at an inflection point. As the body of science and economic research on restoration has grown, so has support among Floridians for the state to move forward with restoration. An SJRWMD online survey conducted from September 23 through October 22, 2021, captured 10,482 responses, of which 9,793, or 93.4% of submittals, indicated a restoration of the Ocklawaha River as the preferred option for the future of the Rodman Reservoir and Kirkpatrick Dam (SJRWMD 2021). A later phone survey conducted in December 2021 and January 2022 with 604 total responses indicated initial support of 77% for Ocklawaha River restoration and only 6% against, with general approval for restoration rising to 81% and those opposed to restoration decreasing to 4% in follow-up questioning (Barcelo 2022).

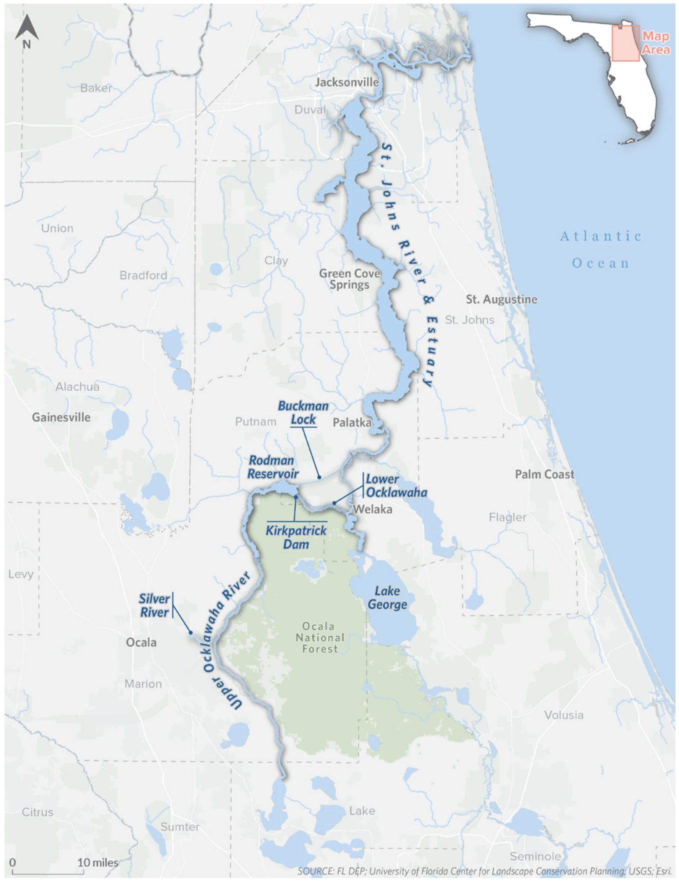


Figure 1. Map depicting the Ocklawaha, Silver, and Lower St. Johns rivers.

A RIVERWAY OF SIGNIFICANCE: THE OCKLAWAHA, SILVER, AND ST. JOHNS

OVERVIEW OF THE RIVERWAY

The Ocklawaha River originates in the Green Swamp, Lake Apopka, and the Harris Chain of Lakes. Additional contributors to its headwaters include Marshall Swamp and Adams Marsh. The Ocklawaha River flows north, toward State Road 40, where it is joined by its largest tributary, the spring-fed Silver River. Smaller springs also contribute to the Ocklawaha's flow, as well as Orange Creek, Deep Creek, and Camp Branch Creek. Prior to the construction of the Kirkpatrick Dam, the Ocklawaha flowed uninterrupted east-southeast from the location of the Kirkpatrick Dam for approximately nine miles, where it joined the St. Johns River around Satsuma. The Kirkpatrick Dam instead directs the Ocklawaha's flow to a spillway, where it runs into the man-made tailrace and the historical Ocklawaha River channel (DEP 2018a). The Lower St. Johns River and estuary flows north from its intersection with the Ocklawaha River approximately 105 miles until it reaches the Atlantic Ocean near Jacksonville (DEP 2018a) (Fig. 1).

THE SIGNIFICANCE OF THE OCKLAWAHA, SILVER, AND ST. JOHNS RIVERS

The Ocklawaha River is an "exceptional ecological and economic resource" and, like the St. Johns River, is one of the few rivers in the nation that flows south to north (DEP 2018b). The Ocklawaha River drainage basin spans approximately 2,800 square miles, while the river flows 78 miles (DEP 2018b). The Ocklawaha is the largest tributary to the longest river in the state—the St. Johns River—and is vital to its 100-mile-long estuary (DEP 2018a; Pinto et al. 2024; Bricker et al. 1999). Owing to its large, sustained artesian spring contribution, the Ocklawaha supplies roughly one-third of the inflow to the Lower St. Johns River during the typical spring dry season (Hendrickson et al. 2015). In total, the Ocklawaha drains 24.3% of the total St. Johns River basin area (Sucsy et al. 2011).

The Ocklawaha River receives a significant portion of its water from the outpouring of Silver Springs, one of the largest artesian springs in the world and the largest spring group, in terms of magnitude, in Florida (DEP 2014; DEP 2015). Silver Springs and the Silver River it feeds provide important habitat for Florida species and have been an outdoor recreation and tourist destination since the late 19th century (DEP 2015). Silver Springs flows into the Silver River, which in turn connects to the Ocklawaha. The Ocklawaha, the Silver, and the St. Johns form a three-part river system that reaches 217 miles from Lake Apopka (headwaters) to the Atlantic Ocean. Their combined watersheds cover approximately 9,500 square miles, or 17.5% of Florida's land area (Appendix C).

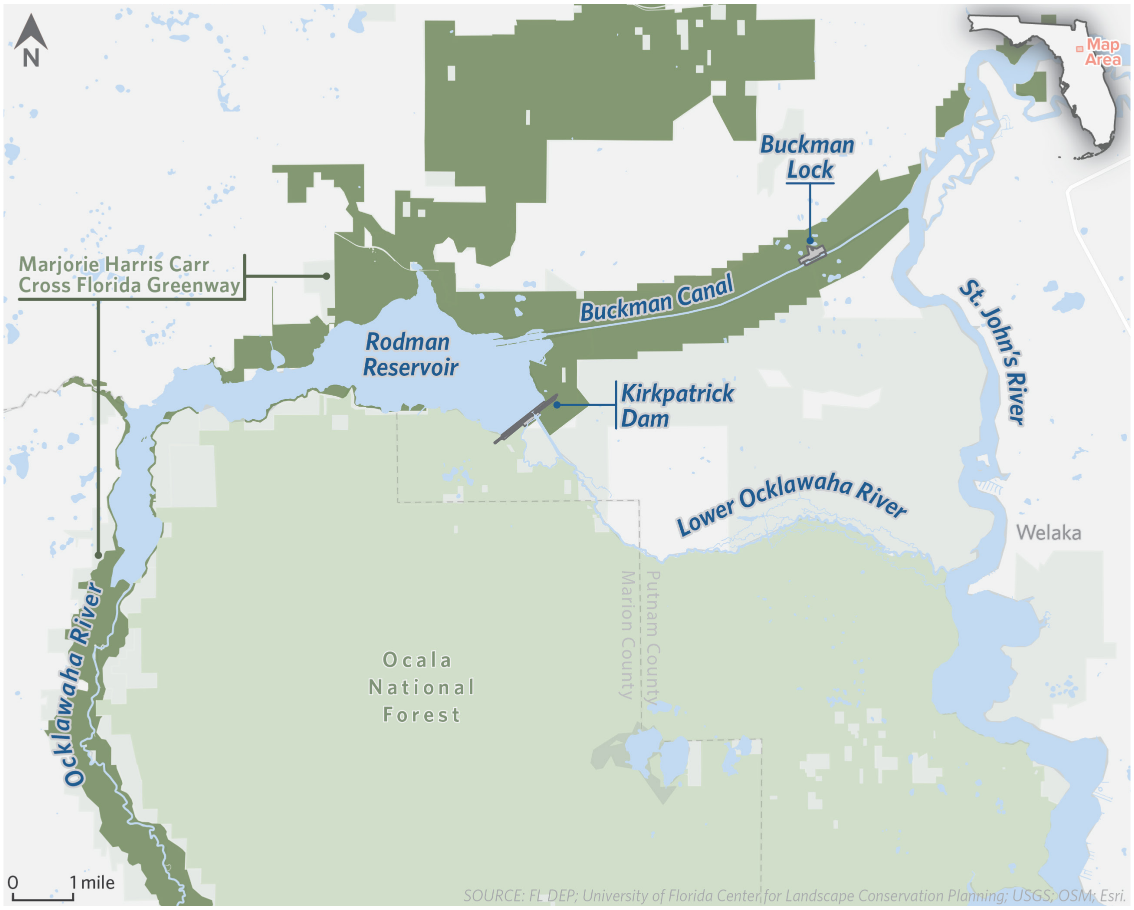


Figure 2. Map centered on general Ocklawaha River Restoration Project area.

THE OCKLAWAHA RIVER RESTORATION PROJECT

Despite cessation of construction of the Cross Florida Barge Canal in 1971, part of the canal was completed, including the Buckman Canal and Lock (connecting the Ocklawaha and St. Johns rivers), Eureka Dam, and Rodman Dam, later renamed the George Kirkpatrick Dam (Fig. 2). The Kirkpatrick Dam is a 22-foot high, 6,800-foot-long earthen structure with four gates and a concrete spillway (Shuman 1995).

The U.S. Department of Agriculture Forest Service granted Florida the occupancy and use of National Forest System lands for the Kirkpatrick Dam, Rodman Reservoir, and Eureka Lock and Dam while the state pursued restoration of the Ocklawaha River (USFS 2001). The associated Final Environmental Impact Statement for restoration of the Ocklawaha River details four alternatives for restoration. Alternative 1 was no action. Alternative 2, partial retention, would include a partial drawdown of the reservoir to an elevation of 14 feet NGVD, with retention of some of the reservoir and restoration of part of the river. Alternative 4, full restoration, would restore the river and floodplain to preconstruction conditions, including removing all structures associated with the dam, canals, and berms, and restoring impacted topography (USFS 2001).

The preferred alternative—Alternative 3, partial restoration—would restore river hydrology and floodplain function in the most environmentally and cost-effective manner, as confirmed by the Florida Legislature in 1996 (DEP 1997). This would include breaching a 2,000-foot section of the Kirkpatrick Dam, closing the Buckman Locks, plugging canal channels intersecting with major creeks, some revegetation for earth stabilization, and permanently lowering the water level to its natural state of 3.8 feet NGVD (USDA 2001).

THE COST OF RESTORATION

In October 2024, RES generated cost estimates for dam removal and river restoration, as described in Alternative 3, partial restoration (Appendix A). Cost estimates were based on quantities of material and equipment specified in the Joint Application for Environmental Resource Permit and Federal Dredge and Fill Permit (DEP 1997), with prices updated to current 2024 dollars. Cost estimates by RES are summarized by major cost category and year (Table 1). Total restoration costs were estimated at $70 million over a period of four years, with initial Year 1 expenses of $21.7 million, then decreasing from $23.4 million in Year 2 to $9.7 million in Year 4.

RESTORATION COSTS

Cost category	*Cost*
First Phase Drawdown	$1,203,800
Improve Forestry Road	$728,016
Improve Southern Borrow Pit	$3,796,558
Dredging	$450,000
Cross Berms (Canal)	$751,098
Deep Creek	$987,023
Ox Bow	$5,430,330
Camp Branch	$9,185,004
Cribbing	$2,098,613
Brush/ Vegetation Strip	$842,421
Pump the Pond Basin	$2,950,416
Second Phase Drawdown	$1,220,000
Blue Spring Yazoo	$248,180
Dam Breach and Southern Dam Removal	$6,059,710
Fill Tail Race & Cross Canal and Removal of the North Dam	$2,281,332
Removal of the Spillway Structure	$768,891
Closing Buckman Locks	$742,000
Portage System	$771,168
Miscellaneous Items	$9,510,000
Design, Modeling, and Permitting, 10%	$5,002,456
Contingency, 30%	$15,007,368
Total	**$70,034,382**
Recreational Improvements, Rodman Area:	
Buckman Lock Recreation Area—St. Johns Loop North & South	
Rodman Recreation Area	
SR310 Bartram Trail and Deep Creek Recreation Site	
Kenwood Recreation Area	
Additional shore fishing platforms on Ocklawaha and St. Johns rivers	
Recreational Improvements, Marion County:	
Ray Wayside Park, Eureka, Orange Springs boat ramps	
Silver Springs State Park: manatee viewing, signage, paddle launch	
Manatee viewing sites (2 sites)	
Gores Landing, Eureka West ramp/dock, Sharpes Ferry park	
Total recreational improvements	**$25,000,000**
Total restoration and recreational improvements	**$95,034,382**

Values in 2024 dollars. Source: RES and Marion County, 2024

Table 1. Summary of estimated costs for dam removal and river restoration by major cost category and year.

Recreational Improvement Costs

In addition to costs for restoration, cost estimates are for illustrative purposes only and are not comprehensive. Recreation infrastructure projects could include, but are not limited to, upgrading the Rodman Recreation Area, repurposing the Buckman Lock Recreation Area, providing supporting amenities for bank fishing and other recreational activities along the restored Ocklawaha River, and modifying existing boat ramps and facilities to be usable after restoration. Consultation with local stakeholders, governments, state agencies, and others during project planning could contribute to a more comprehensive project list and schedule that ensure community needs are adequately addressed. Estimated costs by RES for example improvements in the Rodman area and Marion County total $25 million, including overhead and contingencies, and are assumed to occur in the fourth and fifth years of the project. The total restoration and recreational improvement costs are $95.03 million (Table 1).

Regional Economic Impacts

The economic impacts of Ocklawaha River restoration and examples of recreational improvement spending were evaluated with a regional economic model for Putnam, Marion, and Alachua counties. Economic impact analysis is another way of assessing the economic outcomes of river restoration, treating the restoration spending as a benefit to the area rather than as a cost to state and local government. The project's total spending of $95.03 million is estimated to create 856 job-years of employment, $44.4 million of labor income, $78.3 million value added (GDP), $136.1 million industry output or business sales revenue, $2.32 million in state tax, and $1.69 million in county and subcounty district taxes in 2024 dollars (Table 2). The output impact ($136.1 million) is 1.44 times the total restoration and examples of recreational improvement spending ($95.03 million), implying an overall multiplier effect of 1.44. The largest employment and value added impacts would be for restoration site work (483 job-years, $43.5 million), recreational improvements (225 job-years, $20.2 million), plants and seeds purchased (78 job-years, $8.8 million), and design, engineering, and consultants (56 job-years, $4.9 million), with smaller impacts for planting trees and ground cover (14 job-years, $0.8 million), and motor vehicle purchases (<1 job-year, $0.1 million). Average annual impacts over the five-year project period are 171 jobs, $15.7 million value added, $0.46 million state tax, and $0.34 million local tax. If the recreational improvement spending were reduced to $10 million, overall economic impacts would be 722 job-years and $66.2 million value added.

BENEFIT-COST ANALYSIS

The information on restoration costs, dam operations costs, and projected increases in recreational use under restored river conditions was compiled by year over a 20-year planning period. Overall visitation to the Ocklawaha is estimated to increase by

Table 2. Summary of spending and economic impacts for Ocklawaha River restoration and examples of recreational improvements

Project Component (Industry Sector)	Spending (M$)	Employ-ment (Job-years)	Labor Income (M$)	Value Added (M$)	Output (M$) State	Tax (M$) Local	Tax (M$)
Restoration site work: demolition, earthmoving, dredging, heavy construction (nonresidential construction)	$53.74	483	$24.9	$43.5	$77.2	$0.04	$0.03
Recreational improvements: landings, docks, amenities (nonresidential construction)	$25.00	224	$11.60	$20.2	$35.9	$0.19	$0.12
Design, engineering, and consultants (architecture/engineering services)	$5.47	56	$3.5	$4.9	$8.7	$0.61	$0.39
Plants and seeds (nursery-greenhouse)	$9.98	78	$3.7	$8.8	$13.4	$0.95	$0.76
Planting trees and ground cover (agricultural support services)	$0.60	14	$0.6	$0.8	$0.9	$0.41	$0.29
Motor vehicles (retail auto dealers)	$0.25	<1	$0.0	$0.1	$0.1	$0.13	$0.10
Total	$95.03	856	$44.4	$78.3	$136.1	$2.32	$1.69
Average annual amount over 5 years	$19.00	171	$8.9	$15.7	$27.3	$0.46	$0.34

Values in millions of 2024 dollars. Jobs represent full-time and part-time positions. Job numbers may not sum to total due to rounding. Results include direct, indirect, and induced multiplier effects.
Source: model for Putnam, Marion, and Alachua counties, Florida, 2023 (Implan Group LLC, 2024).

10.5% above the average level over the past six years (359,706 groups during 2017-23), based on the increase in visitation observed during the 2019-20 drawdown of Rodman Reservoir as representative of the restored conditions. It is expected that increased economic output from expanded tourism recreational spending would likely develop over a period of 10 years as wildlife populations recover and native vegetation matures along the riverbanks. In addition, an increase in visitation is expected because of the recreational improvements described above, particularly for manatee viewing at Silver Springs. Although the magnitude of this change is not known, a 10% increase in visitation to Silver Springs above recent annual averages (546,523 visitors, 218,609 groups during 2021-24) is reasonable to expect. These changes in visitation were valued at the average visitor group spending reported in the 2015-16 public survey adjusted for inflation to current dollars ($318). Restoration costs were treated as negative cash flows, while dam/lock cost savings and recreational industry output changes were positive values (benefits) in calculating annual net benefits. The net benefits are negative during the first five years, reflecting the large up-front restoration and recreational improvement costs during this period; net benefits rise to $19.80 million starting in Year 10 (Fig. 3). Total cumulative net benefits over 20 years are estimated at $198.23 million. The benefit-cost ratio for the project is 2.09, meaning that for every dollar of investment, $2.09 in net benefits is generated. The cash flows represent an average annual rate of return on investment (ROI) of 5.4%, and an internal rate of return (IRR) of 14.0% (Appendix B). Applying an annual discount factor of 3% to give benefits and costs in net present value (NPV) terms reduces the benefit-cost ratio to 1.32.

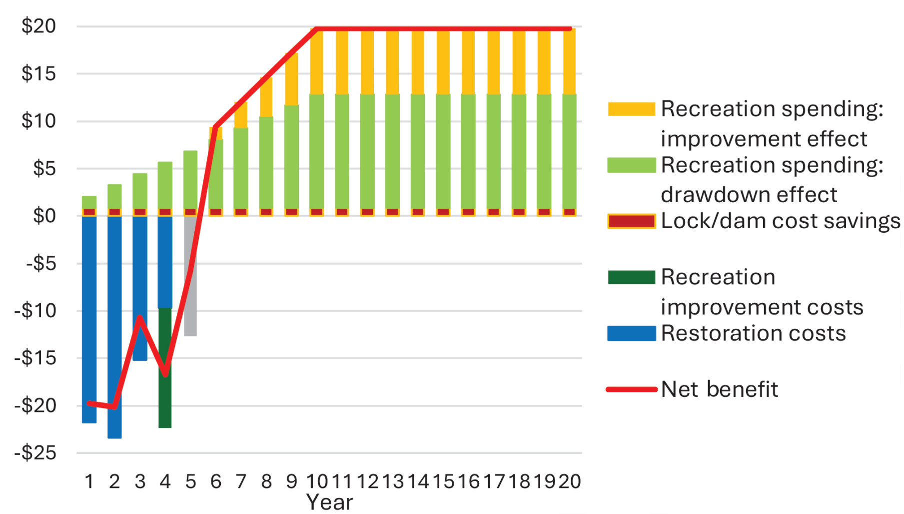


Figure 3. Graph of annual costs and benefits for Ocklawaha River restoration and example recreational improvements over 20 years. Source: RES and Marion County, 2024.

The federally listed endangered Florida panther is a wide-ranging species that depends on landscape-scale habitat connectivity. Strengthening critical connections in the O2O corridor could promote the panther's recovery and expansion north. Credit: Lynn M. Stone

IMPLICATIONS OF RESTORATION FOR PEOPLE AND THE ENVIRONMENT

FLORIDA WILDLIFE CORRIDOR AND ICONIC WILDLIFE

Governor Ron DeSantis signed the Florida Wildlife Corridor Act into law in 2021, designating the 18-million-acre area—roughly the size of South Carolina–as a key goal for the state. The Florida Wildlife Corridor refers to the existing conservation lands and areas for future conservation that rate in the top three priority areas of the Florida Ecological Greenways Network (FEGN), a statewide database that identifies and prioritizes a functionally connected ecological network of public and private conservation lands (DEP 2022). The Ocklawaha River is a major riverine corridor in the Florida Wildlife Corridor's Ocala-to-Osceola corridor (O2O). As a Priority 1 Critical Linkage in the Florida Ecological Greenways Network and in the Florida Wildlife Corridor, the Ocklawaha River is an extremely significant statewide conservation priority. It sits at the center of this system and plays a substantial role in north-south and east-west regional ecological connectivity (Fig. 4).

The O2O corridor covers approximately 1.6 million acres and traverses over 100 miles (North Florida Land Trust 2024). The corridor existing conservation lands and other conservation priority areas from Volusia and Lake counties in central Florida to the Ocala National Forest and to the Osceola National Forest in north Florida and the Okefenokee National Wildlife Refuge in southeast Georgia. It is one of the highest-priority wildlife corridors, providing an essential connection needed to create a statewide wildlife and ecological corridor network, as well as economic, cultural, historical, military, and natural resource value (North Florida Land Trust 2024).

While the 12 counties within the O2O have many lakes, the Ocklawaha stands out as the major, central riverine corridor through this region. The Ocklawaha is also the first critical linkage within the Florida Ecological Greenways Network and the Florida Wildlife Corridor that is represented by active Florida Forever conservation projects intended to close all remaining unprotected gaps within the O2O (DEP 2024c). However, Rodman Reservoir sits in the middle of the O2O and is likely to impede wildlife movement from the Ocala National Forest north to Camp Blanding, Osceola National Forest, and Okefenokee National Wildlife Refuge. Restoring the Ocklawaha River would have a very significant habitat connectivity benefit for wide-ranging and landscape-dependent focal species in Florida, including the federally listed endangered Florida panther, Florida black bear (FWC 2024a) and other focal species that are wide-ranging and fragmentation sensitive (Fig. 7). While there is potential for movement around the reservoir–either to the east between Rodman and the St. Johns River, or southwest across an intact, narrower forested river channel–the broad expanse of open water, invasive aquatic plants, and herbaceous wetlands at Rodman creates at least a significant impediment to all upland-dependent and especially forest-associated species. Furthermore, the canal connecting Rodman to the St. Johns River is an additional partial barrier to wildlife movement especially given its significant width and steep-sided banks.

River restoration, including restoring thousands of acres of forested floodplain habitat, will reestablish an extremely large hub of forested wetlands and floodplain through the entire lower Ocklawaha River valley, creating a pathway that is much better suited for facilitating wildlife movement from Ocala National Forest to conservation lands to the north also within the O2O. A restored Ocklawaha River is an important part of the O2O and will help achieve better functional connectivity for the Florida black bear subpopulations found in Ocala National Forest and Osceola National Forest and serve to help achieve the goals of the Florida Panther Recovery Plan to restore an additional panther population outside of southwest Florida (Humm et al. 2017; USFWS 2008).

In addition, river restoration will also significantly improve ecological connectivity to another corridor of statewide significance within the Florida Wildlife Corridor and the Florida Ecological Greenways Network. This additional corridor traverses from the Ocala National Forest west through Paynes Prairie State Preserve and then further west to Goethe State Forest and the Gulf Coast. This corridor is a very important connector for both the Florida panther and the Florida black bear. It directly links habitat in the Ocala National Forest to the large and protected natural and rural lands along the Big Bend coast. For the Florida black bear, this means connecting two subpopulations with very low genetic diversity, thereby promoting a significant increase in that diversity (Humm et al. 2017).

Restoration of the Ocklawaha River includes restoring 7,500 acres of forested floodplain that existed before the construction of the Rodman Reservoir. Floodplain forests are a rapidly disappearing ecosystem. They are unique in that they support seasonal cycles of flooding and drying that increase productivity and support a diverse community (Knutson and Klaas 1998) of forest-dependent Florida upland, wetland and aquatic species (DEP 2018b). Restoring the Ocklawaha River floodplain forest would allow it to once again

Figure 4. Map of the Florida Wildlife Corridor Ocala-to-Osceola Corridor overlapping the Ocklawaha River, Kirkpatrick Dam, and Rodman Reservoir.

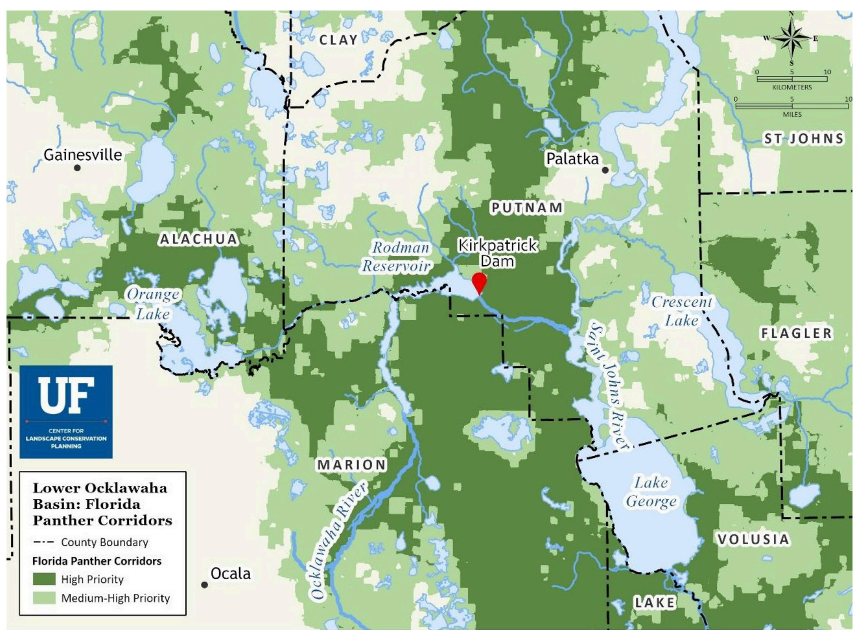


Figure 7. Map depicting medium-high- to high-priority Florida panther habitat suitability abutting the Ocklawaha River, Kirkpatrick Dam, and Rodman Reservoir.

Federally listed threatened Florida manatees depend on freshwater springs as warmwater refuge and submerged aquatic vegetation, such as eelgrass, for food. Restoration could provide manatees new and enhanced access to these key resources. Credit: Bill Hawthorne

stretch from the St. Johns River to the Silver River and to the source of the Ocklawaha River on the north end of the Harris Chain of Lakes. Almost all of this floodplain is within protected conservation lands, and much is surrounded by protected intact upland natural communities (Appendix C). A restored upland-floodplain system would provide diverse and abundant habitat for wide-ranging species including not only panther and black bear, but also many other listed and rare species (Appendix C). Popular game species, including turkey and white-tailed deer, would benefit from restoring this system as well (DEP 2018b).

Florida has made very significant progress protecting the O2O and the Ocklawaha River system. To date this work has primarily entailed land acquisitions through Florida Forever and with support from additional state and federal funding sources, land trusts and other conservation organizations (Fig. 8). Restoring the Ocklawaha River would significantly enhance these conservation investments with essential benefits to state wildlife, ecosystem, and resource-based recreation goals.

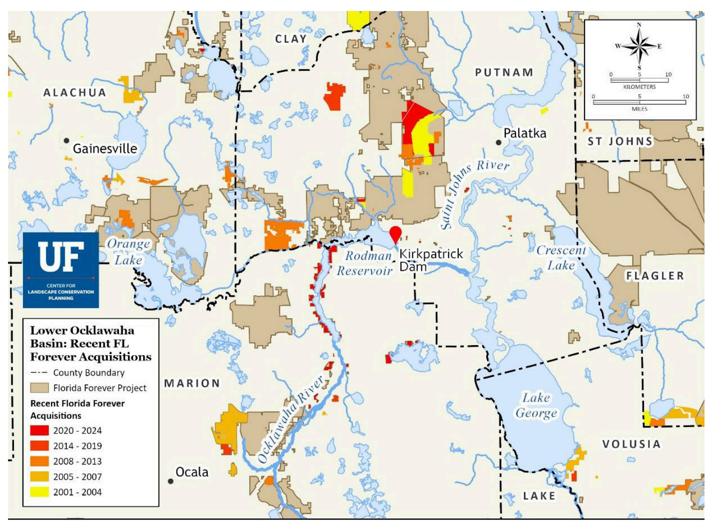


Figure 8: Map of Florida Forever land acquisitions from 2001 to 2024 in proximity to the Ocklawaha River, Rodman Reservoir and Kirkpatrick Dam.

Florida Manatee

The iconic Florida manatee is listed as threatened under the Endangered Species Act and has experienced 12 unusual mortality events over the last decade, including one in 2021 and another in 2022 (NOAA 2024). Manatees depend on warm-water habitats to survive winter months (FWC 2024b). Because of its low metabolic rate (Irvine 1983), prolonged exposure to temperatures less than 68°F can cause cold stress syndrome in manatees, causing possible mortality (Bossart et al. 2002). Manatees therefore depend on warm-water refugia such as natural springs and power plants during winter months (Laist and Reynolds 2005).

One of the most significant threats to manatees is the loss of warm-water refugia (Laist and Reynolds 2005). However, many power plants have closed after reaching the end of their operational lives and the new plants that replaced them use more efficient technologies that shrink the area of warm water by 25% (Laist and Reynolds 2005). The ongoing reduction in artificial warm water sites emphasizes the urgent need for sustainable, natural warm water habitats for manatees (Laist and Reynolds 2005).

Since 1976, the U.S. Fish and Wildlife Service (USFWS) has designated the St. Johns River as critical habitat–habitat that is needed for recovery of a federally listed species–for Florida manatees (Federal Register 1976). In September 2024, USFWS proposed revising the critical habitat designation for the Florida manatee. The proposed action would designate, among other areas, the Upper St. Johns River, including the Ocklawaha River, and Silver Springs as distinct critical habitat units (Fig. 9). The proposal identifies the Upper St. Johns River and Silver Springs units as "some of the farthest inland primary warm-water refuges in the Florida manatee's range." It also "supports expansion and recovery of the regional warm-water network in the Upper St. Johns River Manatee Management Unit because of several lower quality natural refuges or areas available to create new refuges within the unit, thereby supporting expansion and refuge for manatees." Recent studies have documented increased and consistent use of Silver Spring and nearby waters, such as the Ocklawaha, that provide manatee food resources (Ross et al. 2023; Federal Register 2024).

A recent report by Clearwater Marine Aquarium Research Institute highlights an increase in manatee sightings in the spring-fed Silver River over the five years of the survey (Ross et al. 2023). Survey results indicated manatees use the Silver River during the winter and summer. However, manatee movement through the dammed river presents risks. According to the FWC Manatee Mortality Database, there have been 12 manatee deaths associated with the lock and dam system from 1974 to 2020 (Ross et al. 2023). Furthermore, the Rodman Reservoir's temperatures can drop in winter, posing a threat to manatees.

If natural flow were restored, the Ocklawaha and Silver rivers, along with Silver Springs State Park, could provide manatees with improved and, in some cases, new access to vital warm-water refuges during winter, forage, and eliminate the Kirkpatrick Dam and lock infrastructure as a potential source of future mortality. The Florida Fish and Wildlife Conservation Commission and USFWS joint Manatee Warm-Water Habitat Action Plans identify the Ocklawaha River Spring Complex and springs within it as potential essential warm-water habitats (Valade et al. 2020). This includes at least a portion of the Ocklawaha's 20 'lost springs,' which are currently submerged, and the flow of some suppressed, by the reservoir. Restoration could provide manatees new and/or enhanced access year-round to these warm-water habitats of the Ocklawaha River and Silver Springs complex.

New and/or enhanced access for manatees to springs upstream of the Kirkpatrick Dam could also present valuable manatee viewing and ecotourism opportunities in Putnam and Marion counties. For example, Crystal River and Blue Springs are warm-water habitats where manatees are observed during the winter months in high numbers. During the colder months when manatees are present, both Blue Springs State Park and Crystal River National Wildlife Refuge see significant increases in visitors. Each location features viewing platforms where guests can pay admission fees to passively observe the manatees. Manatee viewing at Crystal River and Blue Springs attracts an

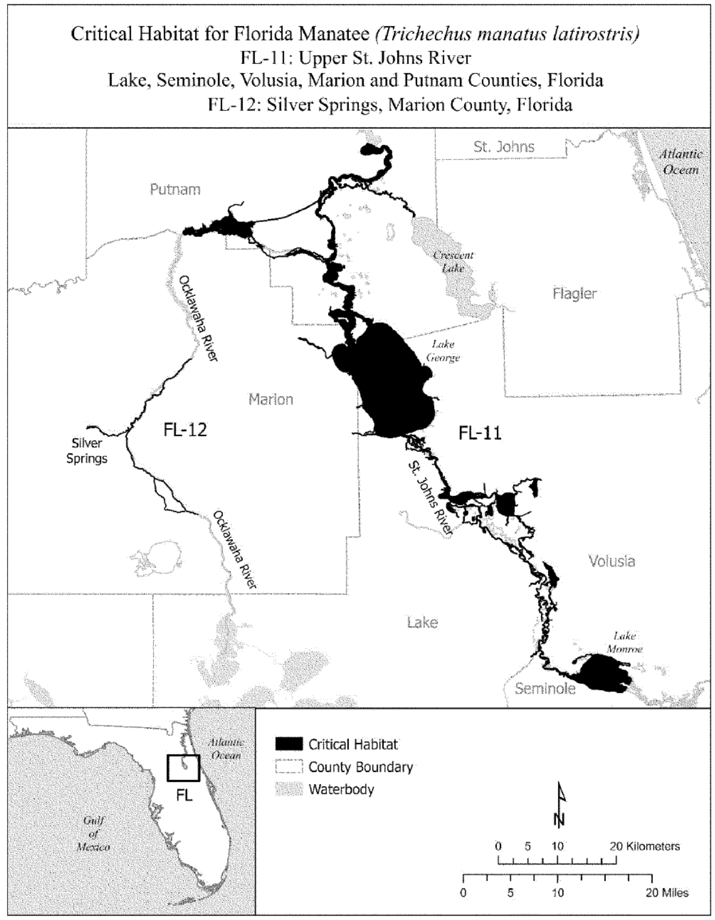


Figure 9. Critical habitat for the Florida manatee. Credit: Federal Register 2024.

estimated 380,000 and 590,000 visitors annually, respectively, which in turn supports businesses such as hotels, restaurants, and tour operators (Ponnampalam et al. 2022).

SILVER SPRINGS AND THE TWENTY 'LOST SPRINGS'

Silver Springs is one of the largest artesian springs in the world, the largest springs group in Florida by magnitude of flow and one of the state's oldest tourist attractions (DEP 2014. DEP 2015). The springs group consists of at least 30 springs (Sutherland et al. 2017). About half of the total water discharge comes from the main headspring, referred to as the Main Spring or Mammoth Spring. Spring discharge has declined over 30% since the 1930s, a shift generally attributed to a combination of changing rainfall/recharge patterns and groundwater withdrawal (Sutherland et al. 2017).

The Silver Springs group is the subject of a number of scientific studies conducted over the past several decades. One of the first modern aquatic ecological studies was conducted by researchers from the University of Florida in the 1950s (Munch et al. 2006). That 1950s study and subsequent research conducted by doctoral students, federal and state agencies, the St. Johns River Water Management District, NGOs, and private consultants provide a good understanding of the changes that have occurred in this ecosystem over the past several decades. The overall condition of Silver Springs has worsened because of declines in spring

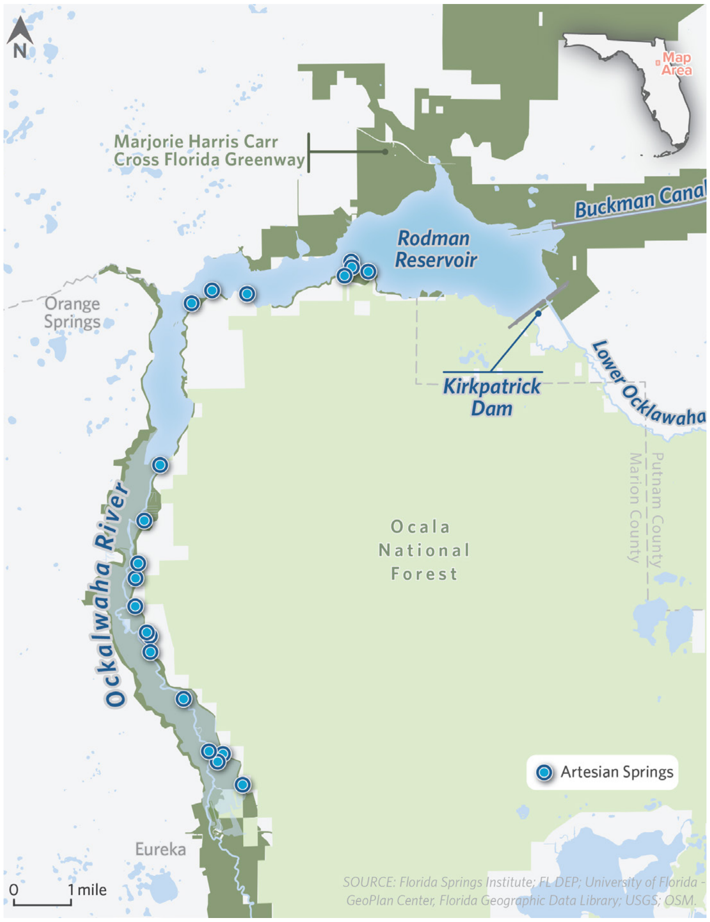
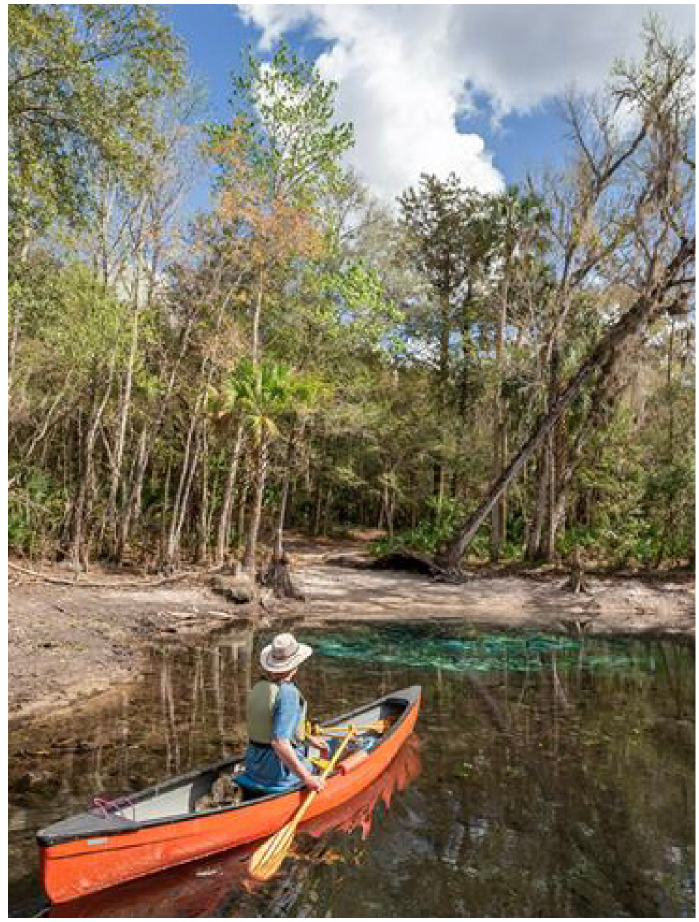


Figure 10. Artesian 'lost springs' that are currently inundated by the Rodman Reservoir.



A paddler explores Cannon Spring during a Rodman Reservoir drawdown event. Cannon Spring is one of approximately 20 'lost springs' currently submerged by the Rodman Reservoir. Credit: John Moran

discharge, significant increases in concentrations and loads of the dissolved nitrogen compound nitrate, increases in the biomass and coverage of benthic, filamentous algae and epiphytic algae, and changes in the fish community, principally declines in biomass (abundance) of certain groups of fishes (Odum 1957; Knight 1980; Munch et al. 2006).

Restoration of the interconnected Silver Springs, Lower Ocklawaha River, Lower St. Johns River and estuary, and South Atlantic Bight marine ecosystem could bring back historic fish communities and enhance access for other species that supported spring and broader river ecosystem health (Hitt et al. 2012; Jordan 1994a, 1994b). Furthermore, grazers, such as Florida manatees, would have much better access to the Silver River/ Silver Springs ecosystem, and would work with restored, native fish communities to naturally manage growth of submerged aquatic vegetation, excessive growth of which has been implicated in disrupting the hydrology of Silver Springs (Sutherland et al. 2017).

In 1971, Elizabeth F. Abbott published a report on "Twenty Springs of the Oklawaha" (Abbott 1971) (Fig. 10). The Rodman Reservoir submerges these springs and, when at full water-level stage, the springs submerged by the reservoir can cease flowing, because of the overlying pressure of the surface water. Flow at Marion Blue Spring drops to zero (no flow) at full reservoir stage, and it appears, based on the data available, that most other springs drop to zero flow or have their flows significantly reduced at reservoir full stage (Hendrickson et al. 2015; SJRWMD 2017).

The partial or complete removal of the Kirkpatrick Dam and restoration of a free-flowing Ocklawaha River would allow the artesian springs to flow continuously and discharge their groundwater to the river. This would restore the groundwater-surface water connections between the river and the Floridian aquifer that historically existed and could increase flow into the Lower Ocklawaha and St. Johns River, while providing thermal refuge habitat for manatees and fish species such as striped bass and sunshine bass. Restored access to these springs via Ocklawaha restoration could generate increased future tourism output and present diverse outdoor recreational opportunities on the Ocklawaha River, such as manatee viewing, swimming, boating, and paddle sport activities, benefiting communities and businesses.

FISH AND FISHERIES

Existing Rodman Fisheries

Rodman Reservoir and the tailwaters below the dam support popular recreational and subsistence fisheries (FWC 2024; DEP 2024a). Quality fisheries for Florida bass and black crappie require intensive management involving drawdowns and extensive aquatic herbicide treatments (Nagid et al. 2015). Before intensive and expensive management activities were implemented, the lake often had large amounts of nuisance aquatic vegetation, and summer dissolved oxygen levels dropped

Florida bass are a target species for local anglers. Fishing opportunities for Florida bass would endure post-restoration and, overall, restoration could provide more diverse and abundant fishing opportunities for a range of fishes. Credit: Bill Hawthorne

below state water quality standards. There were extensive fish kills, and fishing opportunities declined (Knight et al. 2021). Restoration would eliminate costly drawdowns and reduce the need for herbicide treatments—a major issue of concern among recreational anglers–by restoring natural river flow (Knight et al. 2021).

Although the riverine Florida bass and black crappie fisheries would persist following breaching of Kirkpatrick Dam, the restored riverway would provide less fishable area than the 9,500-acre managed reservoir (DEP 2024a). However, viable fisheries for both species in the restored river would still exist. Similarly, closure of the spillway would preclude fishing in the spillway's tailwaters, while providing continued fishing opportunity as those fish make their way upstream and disperse throughout the river system. In addition, the abundance of other sought-after species such as striped bass, channel catfish, white catfish, brown bullhead, redbreast sunfish, and spotted sunfish would likely increase upstream of the current dam, resulting in improved angling opportunities for these species throughout the middle and upper river (Knight et al. 2021). Other recreational and commercial fish species that were historically common prior to the Kirkpatrick Dam and impoundment of the river may also regain access, such as southern flounder, gray snapper, red and black drum, and tarpon (FGFWFC 1976; McLane 1955).

Post-Restoration: More Diverse, Abundant Fish and Fisheries

The American Fisheries Society (AFS) has proposed restoring riverine connections to allow migratory species historic access to more natural channels and floodplains as a priority for protecting the nation's fisheries (Pool 2017). Research based on other dam removal projects suggests fish species diversity in the Ocklawaha River system would increase upstream of the dam after its removal (Bellmore et al. 2019). Removal of the Dead Lake Dam on the Chipola River in the Florida Panhandle resulted in an increase in the total number of fish species sampled upstream of the dam from 31 to 64 (Hill et al. 1994). Similar results have been seen in other dam removal projects (Bellmore et al. 2019). This applies to the Ocklawaha as well, with fish surveys conducted by the FWC in 1976 reporting 49 freshwater fish species in the Ocklawaha River below the dam but only 33 species in Rodman Reservoir (FGFWFC 1976).

Breaching the dam is expected to increase fish species diversity and abundance upstream by providing access to potential historical spawning grounds and nursery habitats for several migratory fish species. These migratory species include the endangered shortnose sturgeon and Atlantic sturgeon, along with American shad, blueback herring, hickory shad, striped bass, and American eel (Hitt et al. 2012; Jordan 1994a). The removal of the dam would lead to increased populations of fish species such as striped mullet and channel catfish, which have significantly declined in the Silver River. This would provide them with better access to the springs, which serve as warm-water habitat, and the upper reaches of the Ocklawaha River (Hitt et al. 2012; Jordan 1994a, 1994b). Other finfish and shellfish, though less abundant in the Ocklawaha River or its tributaries, include several rare or imperiled species that have lost preferred flowing habitats and dispersal pathways, such as darters, shiners, and snails important to river ecology (Jordan 1994b). Breaching the Kirkpatrick Dam would likely promote abundance of those species (FGFWFC 1976), as well as access for many primarily marine or euryhaline fish species (wide salinity tolerance) that were common before the dam's construction, such as Atlantic needlefish, sailfin molly, white mullet, striped mullet, ladyfish, clown goby, and tidewater silverside (FGFWFC 1976; McLane 1955).

American eels are a valuable commercial catch and prey for popular recreational and commercial fish species, including Florida bass, striped bass, and cobia (SCDNR 2015). American eels have experienced significant population declines along the entire East Coast (Haro et al. 2000) and were considered for listing as a threatened species under the federal Endangered Species Act (USFWS 2011). American eels were abundant in the Ocklawaha River before the Kirkpatrick Dam, so much so that thousands of juvenile American eels were observed approximately 30 miles upstream of the existing reservoir (McLane 1955). Dam removals in other areas have benefited this species and it is likely Ocklawaha River restoration could promote American eel abundance by restoring access to nursery habitats upstream (Hitt et al. 2012; Jordan 1994a).

Importantly, restoring the connection between the St. Johns River and Ocklawaha could also help address historic declines of native fish assemblages in the Silver River. In the Silver River, studies by UF, SJRWMD, and others indicate overall estimated annual average fish live-weight biomass has declined in Silver Springs by about 96% since a 1957 study and by 6% since a 1980 study (Munch et al. 2006; Odum 1957; Knight 1980). There were declines in total biomass because of reductions in only a few species (e.g., catfish, mullets, and gizzard shad), while other species had similar abundance across the five decades compared. In the case of catfish and mullets, it is hypothesized that the presence of Kirkpatrick Dam may impede their migratory habitats within the watershed, leading to decreased abundance upstream. More recently, the invasive blue tilapia has multiplied to present approximately 85% of fish biomass in the Silver River (Florida Springs Institute [FSI] 2024). Blue tilapia competes with native species, including Florida bass and sunfish, for spawning areas, food, and space (USFWS 2018). Restoring aquatic connectivity to important habitats could help native fish, such as mullet and catfish, better compete with invasive tilapia.

The Lower St. Johns River season shrimp fishery is popular among shore-based and boat-based recreational and subsistence fishermen.
Credit: Cam Jaggard

Recreational and Commercial Fisheries

Saltwater intrusion along with rapidly changing salinities has an ecological impact on both freshwater and estuarine organisms. Both plants and animals are physiologically adapted to specific ranges of salinity such as fresh, marine, or estuarine; when salinities change, organisms must be able to acclimate or migrate to survive. Restored freshwater flow from the Ocklawaha River could benefit fisheries of the Lower St. Johns River Basin

Box 1: Ecological Implications for Fish Communities Under a Partial Restoration Scenario of the Ocklawaha River

BENEFITS

- **Improved connectivity of upstream-downstream fluvial habitat.**
- **Improved downstream water quality: increased submerged aquatic vegetation (SAV), decreased events of harmful algal blooms (HAB).**

Credit: John Moran

- **Reduced need for intensive management of invasive plants (drawdowns, herbicide treatment).**
- **Restoration of natural floodplain inundation cycle.**
- **Greater access for migratory species to historical habitats.**
- **Increased diversity & abundance of lotic species including some that have declined.**
- **Increased recreational angling opportunities in restored flowing habitats.**
- **Restoration of 7,500+ acres of wetland forest & 20 springs, expanding habitat diversity and thermal refugia for fish species.**
- **Mitigation & improved resiliency for increasing effects of climate change (salt-water intrusion).**

LOSSES

- **Reduced trophy bass & crappie fishery in the reservoir.**

Credit: Cam Jaggard

- **Reduced fish aggregation/ abundance & shoreline angling in the spillway/tailwater fishery.**
- **Limited motor boating accessibility & opportunities for lake fishing.**
- **Existing boat ramps would need to be extended.**

(LSJRB) by providing more favorable conditions for estuarine species and their habitat. Beneficiaries could include a variety of popular finfish and shellfish. These include red drum and spotted seatrout, and shellfish such as blue crabs, which account for most commercial landings in the LSJRB, and shrimp, which support an offshore trawl fishery. A popular seasonal inshore recreational shrimp fishery extends up the LSJRB (Pinto et al. 2024).

Alternatives to Restoration to Mitigate for Fish Passage

There are numerous examples of fish passage structures, such as fish ladders and more nature-like fish ramps. Many are failures or of very low efficacy (Helfman 2007; Kearnan and Waldman 2024; Silva et al. 2018). However, some passage structures are successful. Effective design of fishways is context-specific for individual species or local assemblages under consideration, but, in general, mounting evidence indicates fishways do not provide sufficient restoration of upstream fish passage (Kearnan and Waldman 2024).

The concept of installing a fish passage facility in the Ocklawaha River would require an extensive cost-benefit analysis in the context of evaluating not only design, but also long-term operational requirements and behavioral and physiological characteristics of the species for which a system would be intended to provide passage (both upstream and downstream movements). Complete or partial removal of barriers restores a greater proportion of natural processes than provision of a fishway, which is at best a mitigation measure (Poff and Hart, 2002).

LOWER ST. JOHNS RIVER AND ESTUARY

Increased Flow, Reduced Saltwater Intrusion

The decreased flow from the Ocklawaha River to the Lower St. Johns River is most impactful during Rodman Reservoir drawdowns, which are conducted every three to four years to control invasive aquatic weeds (DEP 2018a). During the refill phase, reduced Ocklawaha flow leads to significant upstream encroachment of marine salinity in the St. Johns River. Between 1997 and 2013, three of the five farthest upstream encroachments of marine salinity were recorded during post-drawdown refills, with the greatest in 2012 reaching nearly to Palatka, 65 miles upstream (Hendrickson et al. 2015). Modeling by the SJRWMD predicted that the 1999 refill increased salinity near the Buckman Bridge by 1.5 practical salinity units (psu), moving the seven-day salinity exposure low stress threshold for submerged aquatic vegetation an additional 2.1 miles upstream (Hendrickson et al. 2015; Dobberfuhl et al. 2012). The Rodman Reservoir also evaporates significant amounts of water—approximately 25% of inflows in certain months – to the atmosphere and suppresses or reverses artesian springs that formerly discharged to the lower Ocklawaha. Lowering water levels during drawdown events temporarily reduced these impacts, with surplus flows calculated during drawdowns ranging between 233 and 459 cubic feet per second (ft^3/s) (Abbot 1971; Hendrickson et al. 2015). Although the net effect on flow to the Lower St. Johns is uncertain, restoration could support increased flow from the Ocklawaha River system and resulting reductions of saltwater intrusion into the St. Johns River (Tibbals 1990).

Improved Water Quality, More Favorable Conditions for Submerged Aquatic Vegetation Recovery

The Ocklawaha River has significantly different water quality compared with the St. Johns River, with higher alkalinity, lower specific conductance, and greater transparency because of its limestone bedrock composition. It also has lower concentrations of total nitrogen (TN) and phosphorus (TP) but higher nitrate+nitrite-N (NOx) levels (Hendrickson 2016).

Initial estimates predicted significant increases in nitrogen and phosphorus loads under a restored, free-flowing Ocklawaha River, which raised concerns for the Lower St. Johns River's water quality and led to the permit being held in abeyance (Hendrickson, 2016). However, an updated analysis showed much lower net differences in nitrogen and phosphorus loads, with all net increases in nitrogen being in the inorganic form of nitrate-nitrite-N, whereas (Hendrickson 2016). Organic and ammonium-N load would actually be reduced under the free-flowing river condition (Hendrickson 2016). The analysis also did not account for nutrient assimilation in the free-flowing river, the import of downstream nutrients by migratory fish (Gende et al. 2002; Garman 1992; MacAvoy et al. 2000), or ongoing restoration programs that have reduced upstream nutrient delivery (Fulton 2020; SJRWMD 2023). Furthermore, data suggest the reservoir's capacity to assimilate phosphorus has declined, potentially increasing phosphorus export to the Lower St. Johns River during drawdowns (Hendrickson et al. 2015). Conversely, the reservoir retains silicates–minerals that can reduce harmful algal blooms by promoting diatoms (Tillmans 2008), which compete with algae and form the basis for healthy freshwater food webs (Humborg et al. 1997; Ittekkot et al. 2000). In summary, the downstream effects of a restored Ocklawaha River could include enhanced water quality and reduced toxic algae blooms in the Lower St. Johns River, primarily because of augmented low flows and a more balanced and timely nutrient supply (SJRWMD 2017).

Eelgrass, also known as tape grass or wild celery, has historically dominated submerged aquatic vegetation beds in the Lower St. Johns River (SJR). However, high water conditions from tropical storms have dramatically reduced SAV coverage (Pinto et al. 2024). The Florida Fish and Wildlife Conservation Commission and fishing and conservation organizations are pursuing eelgrass restoration projects on the St. Johns River (Van Hoose 2024). Restoring the Ocklawaha River system could enhance eelgrass recovery by providing improved water quality in the Lower St. Johns River and a seed source to reestablish SAV beds. Eelgrass seeds do not float, but shoots do, allowing for downstream dispersal (Jarvis and Moore 2008). Breaching the Kirkpatrick Dam could allow beds of eelgrass in the Silver River to provide a seed source for the lower Ocklawaha River and Lower St. Johns River, creating a cascading effect to help promote the recovery of this vitally important habitat.

PUBLIC SAFETY

The National Inventory of Dams identifies the Kirkpatrick Dam and Reservoir as a potential hazard to the downstream area in the event of "failure or mis-operation of the dam or facilities" (USACOE 2023). Kirkpatrick's "high hazard" designation reflects probable loss of human life and impacts on economic, environmental, and lifeline interests (FEMA 2004). Lifeline

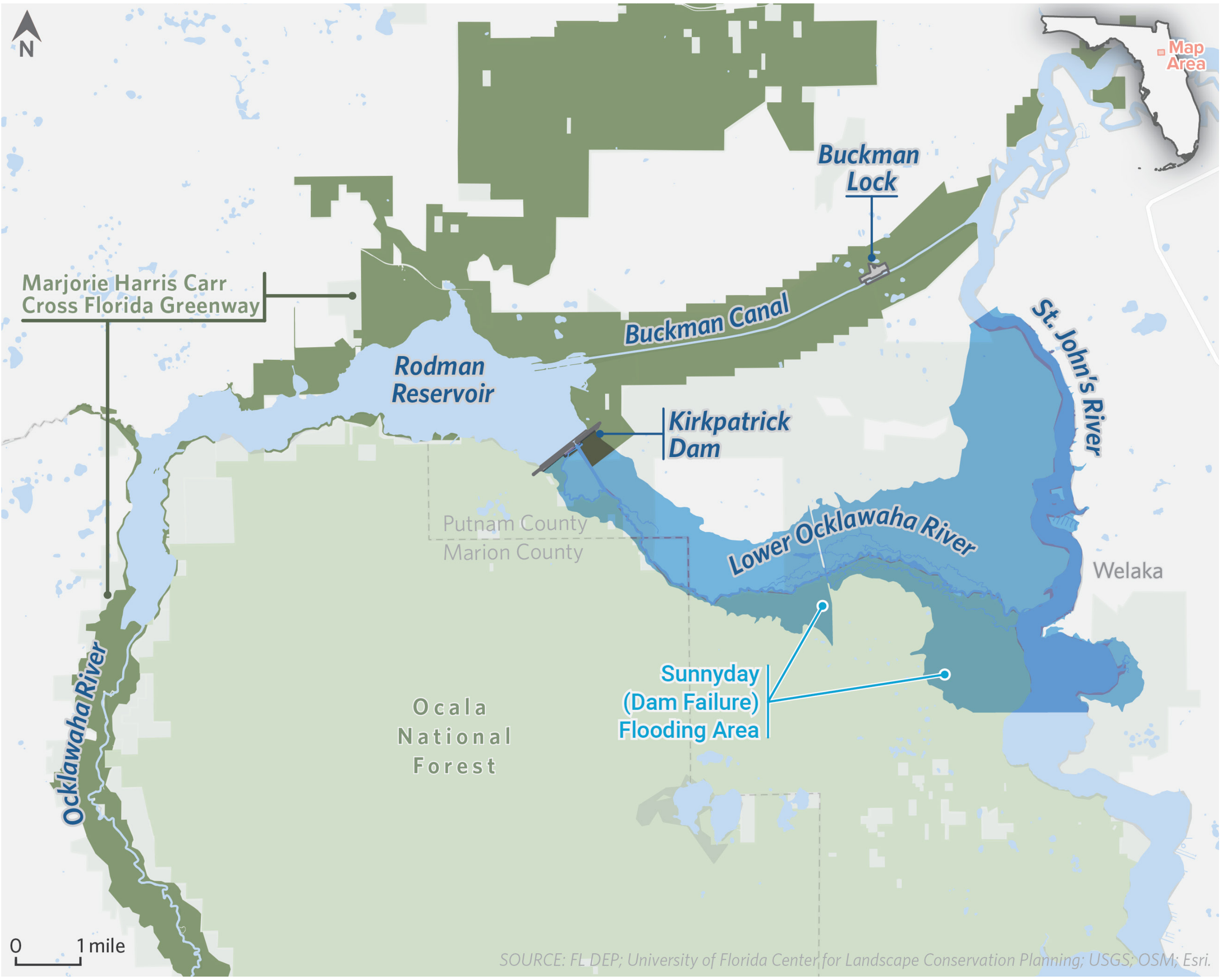


Figure 6. The inundation area at risk in the event of Kirkpatrick Dam failure.

interests refer to critical infrastructure that are essential for the functioning of a community, such as housing and transportation routes (FEMA 2024).The 2007 Emergency Action Plan, Kirkpatrick Dam and Rodman Reservoir prepared by URS Corporation for the DEP identifies a large, approximately 11,000-acre inundation area in Putnam County that could be flooded in the event of a sudden dam failure (Fig. 6) (URS Corporation 2007). A subsequent analysis conducted in 2020 identified 538 properties in that inundation area that, if flooded, could represent a total loss of $57.4 million (Appendix D). A bomb threat in 2023, the age of the dam, and the uncertain condition of dam infrastructure below the waterline demonstrate the potential for such a dam failure event to occur (Cavacini 2023; Mead & Hunt 2021). Note that the classification as a hazard potential does not reflect the current condition of the dam or indicate potential failure (Mead & Hunt 2021).

DEP contracted with Mead & Hunt to produce the most recent inspection report for the Kirkpatrick Dam. Released in August 2021, however, the heavily redacted report did not identify significant areas of deterioration where inspections took place. Wood debris on the upstream side of the spillway prevented divers from performing a complete inspection (Mead & Hunt 2021). The Department of Environmental Protection has canceled the Rodman Reservoir drawdown originally scheduled for winter of 2024/2025 because of persistent high water in the St. Johns River downstream, which could further delay inspection of submerged components of the dam (FWC 2024c).

Flood protection is one of the St. Johns River Management District's (SJRWMD) core priorities (SJRWMD 2024) and can be accomplished via structural flood protection (such as levees and pumps) as well as nonstructural flood protection, including buying and conserving floodplain wetlands that store floodwaters to mitigate potential impacts on communities. Partial restoration would eliminate structural flood hazards associated with the dam by breaching it and restoring flow through the natural Ocklawaha River channel. This project would also provide communities with nonstructural protection in the form of the 7,500 acres restored floodplain forest where the reservoir previously existed that could absorb floodwaters.

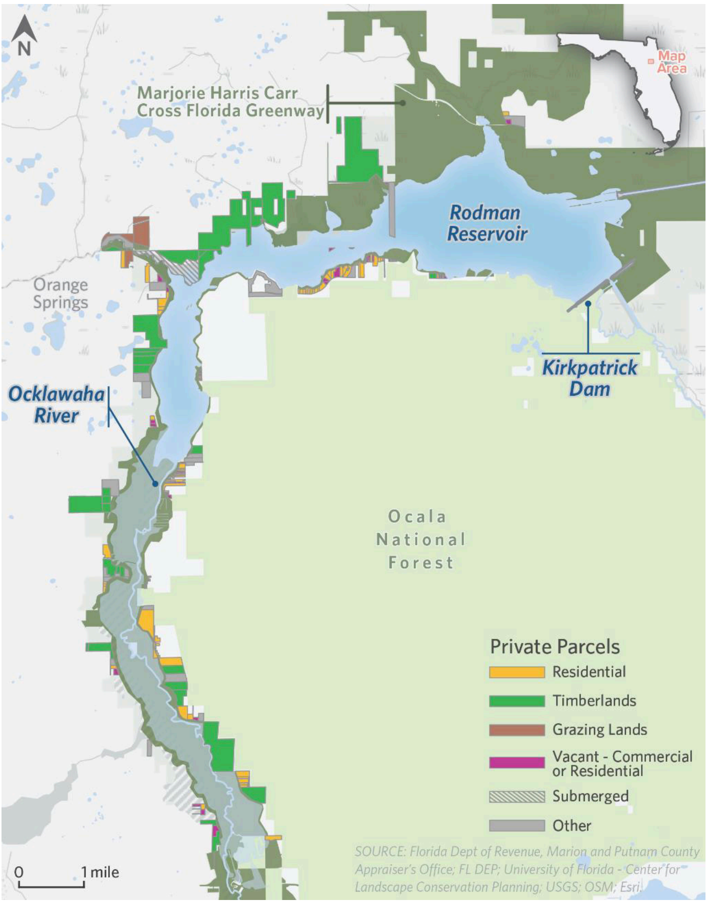


Figure 11. Map of land ownership adjacent to the Rodman Reservoir and Kirkpatrick Dam.

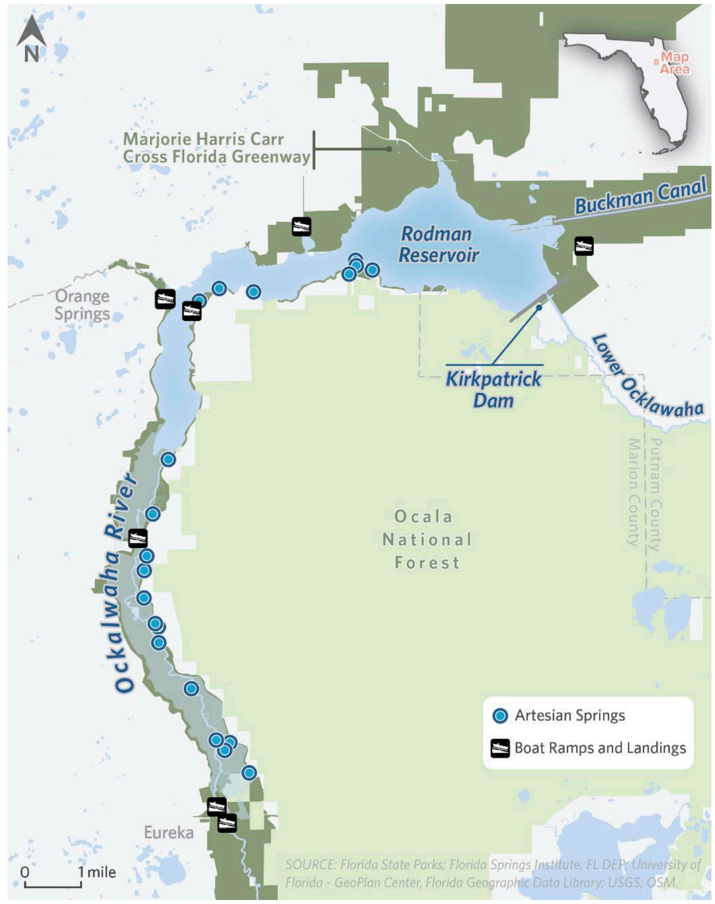


Figure 12. Recreational access points on or adjacent the Rodman Reservoir and artesian 'lost springs' that are currently inundated by the Kirkpatrick Dam and Rodman Reservoir.

OFFSETTING STAKEHOLDER IMPACTS

Restoration of the Ocklawaha River would provide substantial local and regional environmental and economic benefits to a diverse array of Floridians. It would also result in varying levels of impact to a subset of stakeholders who utilize the Rodman Reservoir, Kirkpatrick Dam, and associated infrastructure. Decision-makers are uniquely positioned to address these challenges as part of a comprehensive approach to restoration that accounts for community needs. These impacts and potential solutions to offset them are discussed below.

Private landowners adjacent to the Rodman Reservoir and impounded Ocklawaha River

The state of Florida and the U.S. Forest Service own and manage the majority of lands surrounding the Rodman Reservoir. However, 16 individual private landowners have parcels directly abutting the Rodman Reservoir and/or state lands abutting the reservoir, some of which have waterfront views and access via shore-based launches or docks that, in some cases, encroach on publicly owned lands (Fig. 11). Drawdown of the reservoir and restoration of its floodplain forest could undermine this access and associated property value for private landowners.

Local land trusts, such as the Alachua Conservation Trust, Putnam Land Conservancy, and North Florida Land Trust, are actively working with the DEP to identify willing sellers and acquire and protect lands adjacent to the Rodman Reservoir. As this work progresses, the pool of impacted landowners and opportunities for further encroachment across the Marjorie Harris Carr Cross Florida Greenway lands could continue to decline as more fee simple and conservation easements are executed with willing landowners. Timberlands adjacent to the reservoir could be conserved

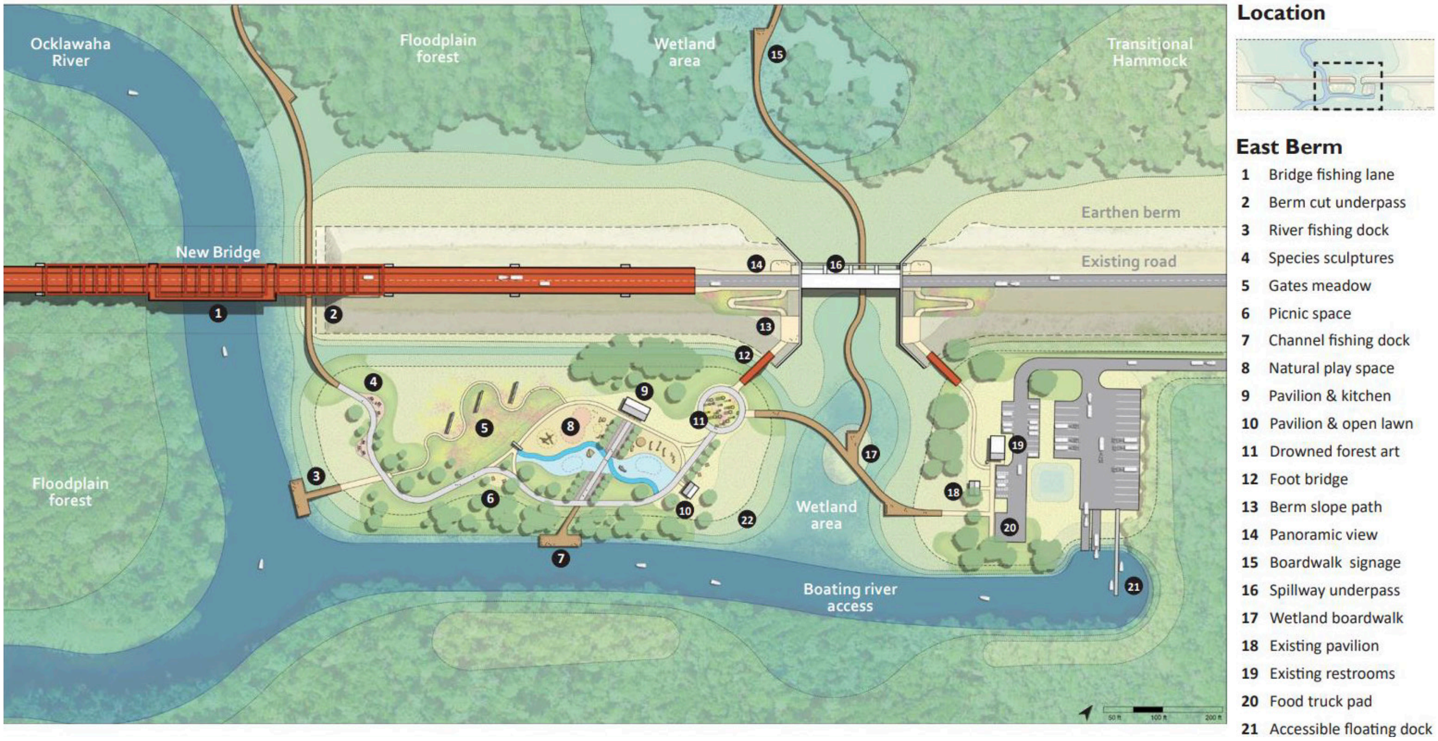


Figure 13. Concept design sketch of potential recreational enhancements to the Kirkpatrick Dam, spillway, and Rodman Reservoir to offset stakeholder impacts and expand recreational opportunities as part of the Ocklawaha River Restoration Project. Credit: Kathryn Stenberg

through easements that would allow the land to remain in use as working lands and for hunting and other income-generating purposes that would continue to generate local tax benefits and valuable ecological benefits. However, land conservation is one of many potential pathways to address impacts to landowners. If restoration is pursued, stakeholder consultations could help identify workable solutions to offset potential impacts and promote continued river access.

Charter, Private Recreational, and Tournament Fishermen

Charter fishing guides and private anglers utilize the Rodman Reservoir, also known as Lake Ocklawaha, to target game fish such as Florida bass and black crappie. The reservoir is a well-known fishing destination that hosts a variety of fishing competitions, including national bass fishing tournaments. The restored riverway would provide less fishable area than the 9,500-acre managed reservoir (DEP 2024a). However, viable fisheries for both species in the restored river would still exist. Additionally, other popular fish such as striped bass, catfish, and sunfish species like popular bluegill and redear sunfish, would likely increase upstream of the current dam (Knight et al. 2021). Specific enhancements to improve fish habitat and abundance of target species, such as Florida bass, could be considered by the state for incorporation into restoration planning in consultation with relevant fishery stakeholders, state agencies, and local governments.

According to survey data, the loss of the Rodman Reservoir fishery could lead some fishermen to target Florida bass and crappie in surrounding areas of Putnam and Marion counties, such as the St. Johns River, Crescent Lake, and Lake Weir (Bi et al. 2019; FWC Undated). However, these survey respondents may have assumed a total loss of fishing opportunities for target species, which would not be the case. Regardless, new and enhanced fishing access opportunities, such as new or expanded boat ramps, at these and other locations could help compensate for potential impacts on fishing access (Fig. 12). Possible recreational improvement costs for specific projects are reviewed in "The Cost of Restoration" section of this report and Appendix B.

Shore-Based and Subsistence Fishermen

The Rodman Recreation Area within the Marjorie Harris Carr Cross Florida Greenway includes a four-gate spillway that discharges water from the Rodman Reservoir. The adjacent bank and two fishing piers provide fishing opportunities to recreational and subsistence fishermen on the downstream discharge side of the spillway (DEP 2024a). Partial restoration would draw down the reservoir water level and decommission the spillway, thereby eliminating this popular tailwater fishery. A comprehensive approach to restoration could enhance and replace these spillway-based fishing sites with new recreational amenities, such as bank and pier-based fishing areas, to promote continued fishing access post-restoration (Fig. 13). There are several riverfront parks along the Ocklawaha River and existing state conservation lands that could be considered for additional freshwater fishing and recreational enhancements.

CONCLUSION

Existing literature, new geospatial analysis, cost estimates and analysis of restoration indicate that restoration could provide overall net public safety, economic, and conservation benefits over continued maintenance and operation of the Kirkpatrick Dam and Rodman Reservoir. Breaching the dam would benefit public safety by eliminating flood hazards associated with the high-hazard dam and providing non-structural flood protection in the form of a 7,500-acre restored floodplain forest. Socioeconomic impacts are anticipated for a limited number of local stakeholders, such as alteration of fishing opportunities, and restoration would require substantial upfront investment, however restoration activities and recreational access improvements are projected to create the equivalent of 859 jobs for one year (i.e., job-years), $44.4 million in labor income, $78.3 million value added (GDP), $136.1 million in industry output or business sales revenue, $2.33 million in state tax, and $1.69 million in county and subcounty district taxes in 2024 dollars. Long-term, restoration would generate cumulative net benefits over 20 years estimated at $198.23 million, where every dollar of investment generates $2.09 in net benefits.

Restoring the river's natural flow would reconnect this important aquatic and terrestrial pathway bolstering state investments in the O2O Corridor and promoting recovery of imperiled species, such as the Florida panther and manatee. The diversity and abundance of native fish species could increase, including species popular among anglers and important to the health of Silver Springs and the Silver, Ocklawaha and St. Johns rivers and estuary. The St. Johns River – Florida's longest river – is anticipated to received increased, unimpeded freshwater flow from the Ocklawaha River that could reduce saltwater intrusion, improve water quality, freshwater food webs and habitat.

A comprehensive approach that enables river restoration, as well as addresses community needs by improving recreational access could maximize the project's economic and environmental benefits. The report provides examples of river-based recreation projects that, if included in restoration, could promote public use of the restored river and associated economic benefits. Florida lawmakers are uniquely positioned to craft a broader strategy that would advance restoration, improve river access and recreation opportunities, and support job creation and economic diversification for local communities and the larger region.

APPENDIX A.
RES COST ESTIMATE FOR THE OCKLAWAHA RIVER RESTORATION PROJECT

res

34 East Pine St.
Orlando, Fl 32801

Corporate Headquarters
6575 West Loop South, Suite 300
Bellaire, TX 77401
Main: 713.520.5400

October 30, 2024

RE: Phase 1 Review
Suggested 2024 Updates to Original Cost Estimate for the Ocklawaha River Restoration Project

Mr. Fitzgerald,

This letter summarizes the cost estimate updates for Ocklawaha River Restoration Project (the "Project"). The cost estimate was performed by reviewing the Joint Application for Environmental Resource Permit (ERP) and Federal Dredge and Fill Permit, dated November 24, 1997 submitted to St. Johns River Water Management District (SJRWMD) and the U.S. Army Corps of Engineers (USACE) by Florida Department of Environmental Protection (FDEP) (Application No. 4-107-0052AG-ERP) (the "Application"). Table 2-2 of Section 2.0 (Design and Construction Methodology) of the Application provided a list of quantities associated with the proposed activities. The Application, including the information contained therein regarding the proposed Ocklawaha River Restoration Partial Restoration Alternative project approach and methodology, reviewed by RES Florida Consulting, LLC ("RES") for the purposes set forth herein, is publicly available.

RES performed a cursory review of the original proposed approach and methodology outlined within the Application, originally completed by FDEP or on behalf of FDEP by a third-party. We believe the approach to be a reasonable representation of future efforts required for the Project. We have assigned present day cost assumptions for each of the units included in Table 2-2 of the 1Application. Based upon the quantities provided in the Application, the updated preliminary cost is approximately ***$70,000,000.***

Included in this estimate is an approximate $5,000,000 (currently estimated at 10% of construction costs) allowance for engineering and design updates, which will be necessary to obtain present day quantities. These design efforts should include updated topographic and bathymetric surveys, as the quantity of material to be dredged and/or excavated will be a significant driver of construction costs. It is highly probable that the volume of dredging has changed over the course of time and this information will need to be updated to obtain accurate pricing from potential contractors. It is important to note that the updated preliminary cost estimate is based on a scope that was developed by FDEP or on behalf of FDEP by a third-party, and is therefore considered highly preliminary. The cost estimate will need to be further fine-tuned after the design and engineering updates are completed.

Additionally, RES used the estimated schedule provided in Figure 2-2 of the Application to anticipate the costs per year for the Project. This estimate is provided below:

Year 1 Cost	Year 2 Cost	Year 3 Cost	Year 4 Cost
$ 21,779,333.82	$ 23,392,983.88	$ 15,173,739.14	$ 9,688,325.09

Thank you,

Joshua Lindstrom

Josh Lindstrom, PE
Project Delivery Manager
jlindstrom@res.us |251.213.8876

Attachments:
Revised Table 2-2 with updated 2024 preliminary pricing

APPENDIX B.
ECONOMIC ASSESSMENT OF OCKLAWAHA RIVER RESTORATION REPORT EXECUTIVE SUMMARY

Introduction

This study examined the economic tradeoffs related to management of the Ocklawaha River, focusing on the value of recreation on the Ocklawaha River and Rodman Reservoir under alternative dam management regimes, economic contributions of river-based and reservoir-based recreation to local economies, and benefits/costs of river restoration. The study examined recreational use of the Ocklawaha/Silver rivers and Rodman Reservoir, including the number of visitors, origin of visitors, types of recreational activities, and differences in recreational use during drawdown and normal water-level management regimes of the Rodman Reservoir. In addition, visitors' willingness to pay for recreational use of the resource was estimated.

Study Methods

Visitors were interviewed at several locations on the Rodman Reservoir, Ocklawaha River, and Silver Springs during February-March in 2016 and 2017. Surveys gathered information on visitors' activities at the site, frequency of visiting locations and distance traveled from home, trip expenditures, demographic characteristics, knowledge, and opinions about alternative management strategies, and expected changes in visitation if the Kirkpatrick Dam were breached. Survey interviews were conducted at five locations: Kirkpatrick Dam and Recreational Areas, Kenwood Landing, Eureka Dam-West, Ray Wayside Park, and Silver Springs State Park river boat launch. A total of 681 interviews were completed over two years, with approximately equal numbers of interviews conducted for each site, and about two-thirds of interviews during weekends. The survey period in February-March of 2016-17 captures the peak season of visitation (March-May) and coincides with the reservoir drawdown during November 2015 to March 2016. Differences in recreational use during the drawdown and normal water levels of the Rodman Reservoir were analyzed using standard statistical methods (Chi-square test, SAS software). Information on visitation was compiled from vehicle counter data for access points shared by the Office of Greenways and Trails and Marion County Department of Parks and Recreation for 17 locations along the Ocklawaha River from Moss Bluff to the Kirkpatrick Dam, excluding Silver Springs State Park.

Direct and indirect economic contributions to the local economy associated with recreational activities and visitor spending were assessed using a regional economic model for Putnam, Marion, and Alachua counties. The model was constructed with IMPLAN software and the associated county database (IMPLAN Group, LLC). Economic contributions were estimated using regional multipliers calculated by the model for each industry sector of economic activity in the regional economy. Economic multipliers represent direct effects for businesses directly associated with serving visitor needs, indirect effects for change businesses supply chains, and induced effects of employee household spending. Economic contributions were evaluated for output (sale revenues), value added (GDP), employment (full-time and part-time jobs), and local, state, and federal taxes.

Visitors' willingness to pay for use of the natural resource was estimated using the travel cost method, which measures the value derived from a trip as a function of the distance traveled, and captures the value perceived beyond the actual costs incurred. The method is widely used by economists to estimate values

Table 1. Number of responses for survey of visitors to Ocklawaha River and Rodman Reservoir

		Number of Responses			
Interview location	*Description of Resource Accessed*	**2016** (reservoir drawdown)	**2017** (normal water level)	**Total**	*Percent of Responses*
Kirkpatrick Dam and Recreation Areas	Rodman Reservoir, Kirkpatrick Dam, spillway canal, and Ocklawaha River below the dam	**77**	**78**	**155**	**22.8**
Kenwood Landing	Rodman Reservoir	**54**	**68**	**122**	**17.9**
Eureka West	Impounded and natural stretches of Ocklawaha River	**76**	**66**	**142**	**20.9**
Ray's Wayside Park	Natural stretch of Ocklawaha River and Silver River	**60**	**50**	**110**	**16.2**
Silver Springs State Park	Silver Springs and Silver River	**73**	**79**	**152**	**22.3**
Total		**340**	**341**	**681**	**100**

Source: Borisova, Bi, Hodges, Holland, 2017.

derived from recreational experiences or subsistence activities. Further details of these methods are given in the journal article (Bi et al. 2019).

Visitor Survey Results

A total of 681 responses were collected across locations (Table 1). Two-thirds of respondents were male (67.3%), and ages ranged from 18 to 93 years, with a median age of 55 years. Many respondents were employed full-time (44.5%) or retired (33.5%). Household income ranged from below $35,000 (20.9%) to $90,000 or more (15.4%), with 43% having household income of $50,000 or more. Almost one-half of respondents (46.3%) had educational attainment of a college degree or higher.

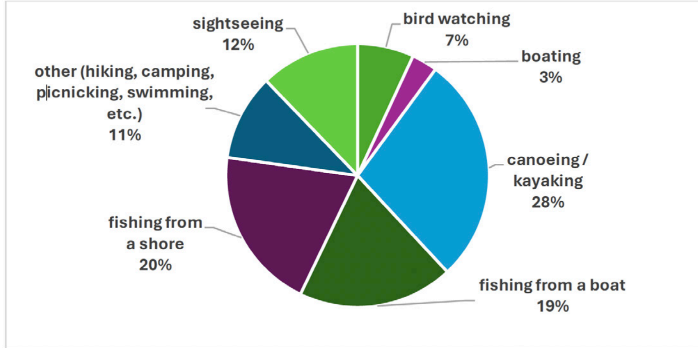
Trip Characteristics. For the majority of respondents, visiting the Rodman Reservoir, Ocklawaha River, Silver River, or Silver Springs was the primary reason for the trip to the area (88.8%). For a minority of respondents (11.2%) who combined outdoor recreation with other activities, the other purposes for the trip included visiting family, friends, or relatives; attending a personal special event, visiting Ocala, or other reasons. Among the interview locations, Silver Springs State Park had a greater share of visitors combining the trip to the park with other activities (19.1% of 152 visitors), compared with 7% to 9.8% of visitors at other locations.

The average trip frequency in 2016 during the reservoir drawdown was significantly higher than in 2017 during normal water levels (24.3 vs. 14.4, respectively), and the share of respondents engaging in nonmotorized boating in 2016 was significantly higher (33% vs. 15%). About 50% of respondents were fishing from a boat or onshore, and their average one-way travel distance was 57 miles. A majority of respondents (75.4%) were return visitors to the area. The percentage of first-time visitors varied among the interview locations, from a high of 43% at Silver Springs to a low of 13% at Kirkpatrick Dam. Among returning visitors, a median of six trips were made to the area in the previous 12 months. Most visitors came to the area for a day trip (82%), rather than staying overnight. The median length of stay for those who visited for more than the day was three nights, and a majority of respondents (81%) indicated staying in the area for one week or less. The most common lodging accommodation was campgrounds (40.2%), followed by hotel/motel (24.1%), family and friends (17.9%), condominium/apartment/rental house (8.9%), and other (8.9%).

Respondents reported an average of 2.32 adults and 0.31 children in the accompanying party. Based on the reported number of days (nights) for the trip, respondents accounted for 2,050 visitor party-days, or 4,590 individual visitor-ays, calculated counting children as one-half visitor day, as is typical in travel, recreation, and tourism studies. In regard to origin of visitors, 55% were nonlocal residents, which was higher for reservoir sites (67%) than for Ocklawaha River sites (48%). Respondents who traveled less than 50 or miles to the site were considered local residents, while those traveling 50 or more miles were deemed nonlocal residents.

Recreational Activities. Respondents were asked to indicate the primary outdoor recreational activity for their immediate group during the trip in one of the following categories: bird watching or wildlife viewing; canoeing, kayaking, paddleboarding; boating (motorized), jet skiing; fishing from a boat; fishing from a pier or shore; sightseeing (2017 survey only); other not specifically listed; not sure, refused to answer. The distribution of activities is shown in Figure 1. Overall, 39% of participants were engaged in fishing-related activities, and the remaining 61% were in other activities. Respondents engaged in canoeing, kayaking, paddleboarding, bird watching, and some other activities were more likely to report that they were part of a larger group.

Figure 1. Distribution of recreational activities at Ocklawaha River and Rodman Reservoir (number adults)



Source: Borisova et al. 2017.

The mix of recreational activities differed across interview locations. Visitors at the Kirkpatrick Dam and Rodman Recreation Areas were primarily engaged in shore fishing, while visitors at Kenwood Landing were mostly fishing from a boat, visitors at Eureka West participated in a mix of activities, and Ray Wayside Park was dominated by canoeing/kayaking/paddleboarding. At Silver Springs State Park, sightseeing and other activities accounted for more than one-half of all visitors. Canoeing, kayaking, and paddleboarding were more popular activities in 2016 during the drawdown period than in 2017 during the normal reservoir management regime.

Shore fishing represents a majority of respondents at Kirkpatrick Dam and the Rodman Recreation Areas. In 2017, most shore fishing occurred on the spillway canal (49%), Rodman Reservoir (38%) and the natural stretch of the Ocklawaha River below the dam (13%). Shore fishing visitors cited reasons for the chosen location including "familiarity with the site," "fishing opportunities other than bass," and "proximity to home." Boat fishing represents a majority of visitors at Kenwood Landing on the Rodman Reservoir (70%); boat fishing also occurs at Eureka, Ray Wayside and Kirkpatrick Dam. Reasons for selecting locations for boat fishing included "familiarity with the site," proximity to home, number of fish caught per hour, and availability of a boat ramp. Trophy bass fishing opportunities were relatively more important for selecting Kenwood Landing, while proximity to home and availability of a boat ramp were more important at Ray Wayside Park and Eureka visitors.

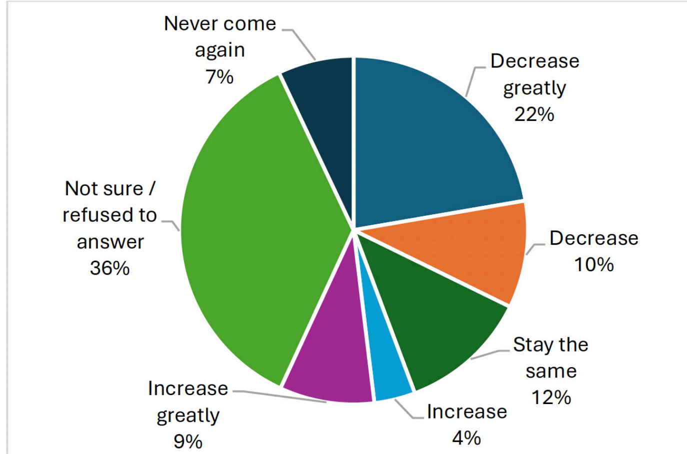
Canoeing, kayaking, and paddleboarding were popular activities at Silver Springs State Park, Ray Wayside, and Eureka locations, but not at all at Kenwood Landing or Kirkpatrick Dam, which is not surprising since canoeing and kayaking are primarily river-based activities. A majority (85%) of paddlers visited the Ocklawaha River south of Eureka, Silver Springs/Silver River during normal water levels, but a slightly higher level visited the

Ocklawaha River during drawdown in 2016. Paddlers offered a variety of reasons for selecting a particular location, such as recommendations by friends, proximity to Silver River, quietness and peacefulness of the place, as well as proximity to home and familiarity with the site. Visitors engaged in other activities such as bird watching, motorboating (without fishing), picnicking, sightseeing, and hiking mainly at Silver Springs State Park, Ray Wayside Park, and Eureka West.

Awareness and Effects of the 2016 Rodman Reservoir Drawdown. During the 2016 drawdown of the Rodman Reservoir, a majority of respondents were aware of the drawdown. Awareness of the drawdown was higher at locations around the Rodman Reservoir and much less so at Silver Springs. A majority at Kenwood Landing reported being impacted. Overall, most respondents (76%) did not feel any positive or negative impact from the drawdown, while 21% did report an impact on their trip, and 3% were not sure/refused to answer. People engaged in shore or boat fishing reported being impacted more positively than negatively in terms of number of fish caught. A few other respondents mentioned that the drawdown provided more birds/wildlife to observe, made submerged springs visible, and increased water transparency.

Knowledge and Opinions about the Fate of Rodman Reservoir and Kirkpatrick Dam. Overall, less than half (45%) of respondents indicated that they were not at all informed about the debate around the future of the Kirkpatrick Dam/Rodman Reservoir, while 55% were somewhat or very informed. Awareness differed among the interview locations, with the greatest number of very informed respondents at the locations around the reservoir. When asked about preferences for the fate of the Rodman Reservoir and Kirkpatrick Dam, a majority of respondents (56%) indicated that they would leave the dam as is, while 15% supported breaching the dam, and 29% were not sure or refused to answer. For respondents at four locations excluding Silver Springs State Park, a higher share had either a positive or negative opinion, with support for breaching the dam increasing to 19%, and support for keeping the dam increasing to 60%. When asked about reasons for their opinion on the future of the dam/reservoir, respondents who supported breaching the dam stated that this would restore Silver Springs and the Silver River, improve or protect aquatic ecosystems, restore submerged springs, and improve or protect birds and wildlife habitat. Supporters of keeping the dam and reservoir primarily thought that this would protect or improve fishing. In the 2017 survey, when respondents were asked whether their visitation to the area would change if the Kirkpatrick Dam were breached, 39% indicated that their visitation would decrease or they would never return, 13% would increase, 12% would stay the same, and 36% did not answer (Fig. 2). Among those who stated that they would stop visiting or decrease their visitation, the median number of trips to the area was higher compared with other visitors, but those who said that they would increase visitation tended to come in larger groups. When asked about alternative sites for recreation, many who said that they would decrease or stop visiting indicated a number of suitable alternate sites nearby, including the St. Johns River, Santa Fe Lake, Lake Lochloosa, Lake George, and Orange Lake. These results suggest that even if Rodman Reservoir visitation were to decrease, recreation activity in the region might stay the same, with respondents switching to nearby sites.

Figure 2. Responses regarding visitation to the area if the dam were breached



Source: Borisova et al. 2017.

Table 2. Average annual visitor groups to Ocklawaha River and Rodman Reservoir recreation sites, 2013-17

Site Type	Recreation Access Site	Number Groups
Reservoir	Buckman Lock	6,887
	Rodman Campground	35,137
	Rodman Road East Side	20,133
	Kenwood Road	24,519
	Hog Valley	18,690
	Orange Springs Boat Ramp	24,938
	Rodman Rec Area-East	38,156
	Rodman Rec Area-West	30,670
River	Ray Wayside Park	53,027
	Moss Bluff Park South	32,116
	Moss Bluff Park North	28,981
	Eureka Boat Ramp East	14,962
	Eureka Boat Ramp West	21,656
	Gores Landing	6,255
	St. Johns Trail Loop-South	5,527
Total	all sites less duplicated counts	361,655

Data for Silver Springs not included. Sources: Florida Department of Environmental Protection Office of Greenways and Trails, and Marion County Department of Parks and Recreation; analysis by Borisova et al. 2017.

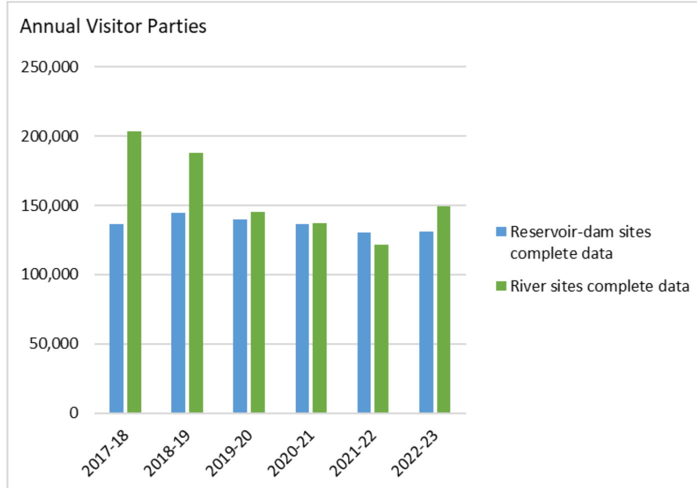
Visitation to Ocklawaha River and Rodman Reservoir.

Data on visitation to the Ocklawaha River and Rodman Reservoir was compiled for 15 access points monitored by the Florida Department of Environmental Protection Office of Greenways and Trails and the Marion County Department of Parks and Recreation. Vehicle count data represents the number of visitor groups. Information on monthly visitation was obtained from July 2002 through June 2017, with some missing data for short periods. The largest numbers of visitors were during the cool-season months October through April, with monthly visitation ranging from 18,000 to 39,000. Visitation during 2013-17 was taken as representative of current conditions for economic analysis (Table 2). Recreation sites were categorized as either

"River" or "Reservoir" locations, depending upon whether they provided access to the natural stretches of the Ocklawaha River or Rodman Reservoir, respectively. Average annual visitation for all sites (361,655) was higher at Ocklawaha River sites than at Rodman Reservoir sites.

Additional information on visitation was obtained for the more recent period of July 2017 through September 2023 to compare with previous findings. Annual visitation to river sites declined over this period, while visitation to dam-reservoir sites remained more stable for sites with complete data over the period (Fig. 3), in contrast to the earlier data for 2004-17. This more recent period included the Rodman Reservoir drawdown during November 2019 through February 2020. These results confirm earlier findings that visitation to dam-reservoir sites increased during the drawdown months compared with the same months in other years (21.5%), while visitation to river sites increased slightly (2.3%).

Figure 3. Summary of annual visitor groups to Ocklawaha River and Rodman Reservoir recreation sites, 2017-23



Source: Florida DEP-Office of Greenways and Trails, and Marion County Department of Parks and Recreation.

Visitor Recreational Spending. Visitor spending is a key indicator of demand for recreational activities and amenities. To measure visitor spending, survey respondents were asked to provide information on their current trip expenditures in 11 categories. Trip expenditures were reported by survey respondents either as a specific value or as a range of values with the midpoint taken as a point estimate. Visitor expenditures were expressed on a per group-day or per person-day basis by dividing total reported expenditures by the number of groups, group size, and days stayed. In addition, spending results were adjusted to account for differences in likelihood of sampling in the survey for local residents who may make more trips to the recreation area, known as avidity bias (Thomson, 1991). Expenditures reported by survey respondents were summarized by type of recreational site (river, dam-reservoir), and residence location (local, nonlocal). Total trip spending per person-day averaged over $90 for visitors at dam-reservoir sites, and nonlocal visitors at river sites, but was much lower for local visitors at river sites (Table 3). Average expenditures per group-day were multiplied against the average annual number of local and nonresident visitor groups during 2013-17 to estimate total annual visitor spending of $23.32 million, including $9.88 million for visitors to dam-reservoir sites and $13.44 million for visitors to river sites, with a higher share of spending by nonlocal versus local visitors at both dam-reservoir sites ($5.66 vs. $4.22 million) and river sites ($10.20 vs. $3.24 million).

Economic Impacts of Visitor Spending. Economic impacts of recreational visitor spending were estimated using the visitor spending and annual visitor numbers in 2013-17 cited above, together with economic multipliers from a regional economic model for the Putnam-Marion- Alachua County area (Implan Group). The total economic impacts included employment of 356 full-time and part-time jobs, $16.23 million in value added contribution to gross domestic product (GDP), $10.26 million in labor income, and $28.30 million in industry output or revenues (Table 4). The impacts of Ocklawaha River-based recreational sites (201 jobs, $9.65 million GDP) were higher than for Rodman Reservoir sites (155 jobs, $6.58 million GDP) primarily because of a greater number of annual visitors.

Table 3. Estimated visitor expenditures per person-day by type of recreation site and visitor origin

	Reservoir		River	
Expense category	**Local**	**Non-local**	**Local**	**Non-local**
Restaurants/bars	$20.81	$12.28	$3.72	$14.08
Food/beverages at stores	11.22	6.47	6.83	14.73
Lodging	14.64	15.31	0.06	27.24
Rental vehicle	2.32	2.30	0.01	2.74
Gasoline/oil	17.71	11.14	10.52	17.21
Fees (parking, admission, etc.)	10.29	3.45	0.09	1.28
Transportation (bus, taxi, sightseeing tours	2.93	2.11	0.49	7.51
Entertainment (attractions, concerts, movies)	1.34	1.92	0.09	1.10
Recreation gear (fishing, boating, cycling)	4.53	1.72	2.76	2.15
Shopping (clothing, gifts, etc.)	8.46	6.28	1.51	3.03
Other	3.62	1.93	0.58	1.72
Total trip expenditures	$97.86	$64.92	$26.67	$92.80

Source: Bi et al. 2019.

Table 4. Economic impacts of annual recreation spending at the Ocklawaha River and Rodman Reservoir

Site Type	Industry Output (Revenues)	Value Added (GDP)	Labor Income (Wages, Salaries, Benefits)	Employment (Full-time, Part-time Jobs)
Rodman Reservoir	$11,561,386	$6,580,767	$4,185,320	155
Ocklawaha River	$16,741,385	$9,650,026	$6,072,109	201
Total	$28,302,771	$16,230,793	$10,257,429	356

Values in 2017 dollars.
Source: IMPLAN model for local area (Implan Group LLC, 2015), and analysis by Bi, Borisova, Hodges, 2019.

Willingness to Pay for Recreation. The willingness to pay or "consumer surplus" for recreation in the area was estimated using the survey data on frequency of visits in the last 12 months and home ZIP code, together with the travel cost method, as described above. The econometric model predicted the number of trips to the area as a function of travel cost, household income, gender, and whether the person engages in fishing. The estimation excluded respondents traveling more than 500 miles. As expected, the number of trips is negatively related to the distance to the site, and positively related to the distance to an alternative site. Visitors engaged in fishing reported a greater number of visits to the area than visitors in the other types of activities, and females tended to visit less frequently than males. The model estimated the median value that visitors derive from their trips to the Ocklawaha region as $112 per group per year. Given the average annual number of visitor groups to the area, the estimated aggregate annual consumer surplus for visitors to the area is $6.2 million, including dam-reservoir sites ($2.23 million), and river sites ($3.97 million). Further details of the methodology and results are given by Bi, Borisova, and Hodges (2019).

Costs and Benefits of Ocklawaha River Restoration

Results from on-site visitor surveys, historic visitation patterns, and regional economic analysis were combined with restoration cost projections and savings imputed for reduced operating and maintenance costs for the Kirkpatrick Dam to evaluate costs and benefits of Ocklawaha River restoration.

Dam Removal and River Restoration Costs. Costs for dam removal and river restoration were taken from the assessment by RES (Appendix A). Restoration would involve breaching a 2,000-foot section of the Kirkpatrick Dam, closing the Buckman Locks, plugging canal channels intersecting with major creeks, some revegetation for earth stabilization, and permanently lowering the water level to 3.8 feet NGVD, as described USDA-Forest Service (USFS 2001). Cost estimates were based on quantities of material and equipment specified in the Joint Application for Environmental Resource Permit and Federal Dredge and Fill Permit (DEP 1997), with prices updated to current 2024 dollars. Cost estimates by RES are summarized by major cost category and year (Table 5). Total restoration costs were estimated at $70.0 million over a period of four years, with costs decreasing from $23.4 million in Year 2 to $9.7 million in Year 4. Costs include $5 million for updated engineering and design for current quantities for volumes of dredged material that may have changed since the original

Table 5. Summary of estimated costs for dam removal and river restoration by major cost category and year.

Cost category	***Cost***
First Phase Drawdown	$1,203,800
Improve Forestry Road	$728,016
Improve Southern Borrow Pit	$3,796,558
Dredging	$450,000
Cross Berms (Canal)	$751,098
Deep Creek	$987,023
Ox Bow	$5,430,330
Camp Branch	$9,185,004
Cribbing	$2,098,613
Brush/ Vegetation Strip	$842,421
Pump the Pond Basin	$2,950,416
Second Phase Drawdown	$1,220,000
Blue Spring Yazoo	$248,180
Dam Breach and Southern Dam Removal	$6,059,710
Fill Tail Race & Cross Canal and Removal of the North Dam	$2,281,332
Removal of the Spillway Structure	$768,891
Closing Buckman Locks	$742,000
Portage System	$771,168
Miscellaneous Items	$9,510,000
Design, Modeling, and Permitting, 10%	$5,002,456
Contingency, 30%	$15,007,368
Total	**$70,034,382**
Recreational Improvements, Rodman Area:	
Buckman Lock Recreation Area—St. Johns Loop North & South	
Rodman Recreation Area	
SR310 Bartram Trail and Deep Creek Recreation Site	
Kenwood Recreation Area	
Additional shore fishing platforms on Ocklawaha and St. Johns rivers	
Recreational Improvements, Marion County:	
Ray Wayside Park, Eureka, Orange Springs boat ramps	
Silver Springs State Park: manatee viewing, signage, paddle launch	
Manatee viewing sites (2 sites)	
Gores Landing, Eureka West ramp/dock, Sharpes Ferry park	
Total recreational improvements	**$25,000,000**
Total restoration and recreational improvements	**$95,034,382**

Values in 2024 dollars. Source: RES and Marion County, 2024

Table 6. Summary of spending and economic impacts for Ocklawaha River restoration and recreational improvements

Project Component (Industry Sector)	Spending (M$)	Employment (Job-years)	Labor Income (M$)	Value Added (M$)	Output (M$) State	Tax (M$) Local	Tax (M$)
Restoration sitework: demolition, earthmoving, dredging, heavy construction (nonresidential construction)	$53.74	483	$24.9	$43.5	$77.2	$0.04	$0.03
Recreational improvements: landings, docks, amenities (nonresidential construction)	$25.00	224	$11.6	$20.2	$35.9	$0.19	$0.12
Design, engineering, and consultants (architecture/engineering services)	$5.47	56	$3.5	$4.9	$8.7	$0.61	$0.39
Plants and seeds (nursery-greenhouse)	$9.98	78	$3.7	$8.8	$13.4	$0.95	$0.76
Planting trees and ground cover (agricultural support services)	$0.60	14	$0.6	$0.8	$0.9	$0.41	$0.29
Motor vehicles (retail auto dealers)	$0.25	<1	$0.0	$0.1	$0.1	$0.13	$0.10
Total	**$95.03**	**856**	**$44.4**	**$78.3**	**$136.1**	**$2.32**	**$1.69**
Average annual amount over 5 years	**$19.00**	**171**	**$8.9**	**$15.7**	**$27.2**	**$0.46**	**$0.34**

Values in million 2024 dollars. Jobs represent full-time and part-time positions. Job numbers may not sum to total due to rounding. Results include direct, indirect, and induced multiplier effects. Source: model for Putnam, Marion, and Alachua counties, Florida, 2023 (Implan Group LLC, 2024).

estimates developed over 20 years ago. In addition, a 30% contingency of $15.01 million was included to account for unforeseen expenses, as is typical for planning-level cost estimates. Note that these costs are substantially higher than the $25 million estimated in 2001 because of price inflation.

Recreational Improvement Costs. In addition to costs for restoration, cost estimates were developed for example recreational improvements to ensure continued access and increase visitation. These projects and associated cost estimates are for illustrative purposes only and not comprehensive. Incorporating consultation with local stakeholders, governments, state agencies, and others into project planning could contribute to a more comprehensive project list and schedule to ensure

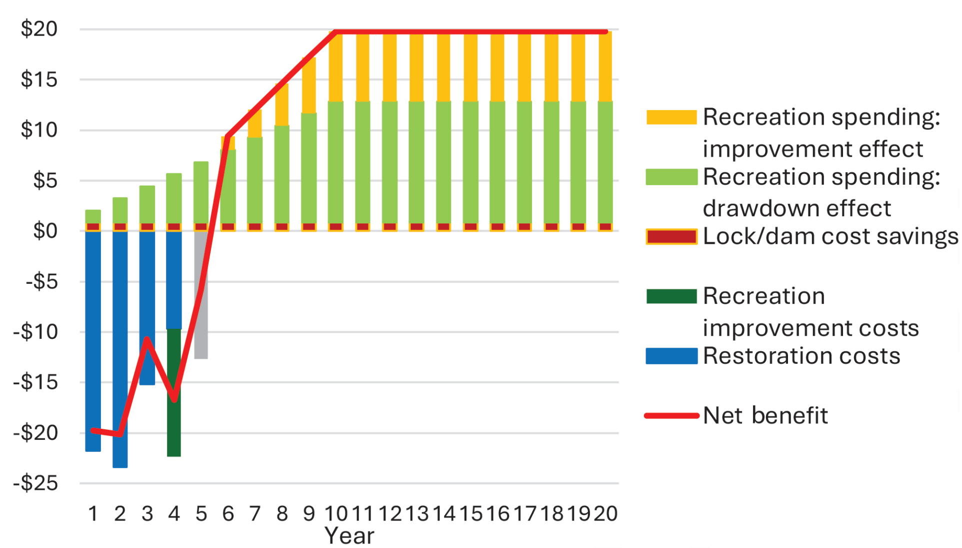


Figure 4. Graph of annual costs and benefits for Ocklawaha River restoration and example recreational improvements over 20 years.

community needs are addressed. Estimated costs by RES for example improvements in the Rodman area and Marion County total $25 million, including overhead and contingencies, and are assumed to occur in the fourth and fifth years of the project. The total restoration and example recreational improvement costs are $95.03 million (Table 5).

Regional Economic Impacts of River Restoration and Recreational Improvements

In addition to the benefit-cost assessment discussed previously, economic impact analysis is another way of assessing the economic outcomes of river restoration, treating the restoration spending as a benefit to the local area rather than as a cost to state and local government. The economic impacts of Ocklawaha River restoration and recreational improvement spending were evaluated with a regional economic model for the three-county area of Putnam, Marion, and Alachua counties (Implan Group, LLC). The model estimates direct, indirect, and induced multiplier effects representing restoration spending, supply chain activity, and employee household living expenses, respectively. Proposed project spending was entered into the model in appropriate industry sectors corresponding to major project components or expense categories.

The spending and economic impacts for the project are summarized in Table 6, with total spending of $95.38 million, that is estimated to create 856 job-years employment, $44.4 million in labor income, $78.3 million value added, $136.1 million in industry output or business sales revenue, $2.32 million in state taxes, and $1.69 million in county or subcounty district taxes, all in 2024 dollars. Note that value added is equivalent to GDP as a preferred measure of gross personal income, business net income, and taxes. The output impact ($136.1 million) is 1.44 times the total restoration and recreational improvement spending ($95.03 million), implying an overall multiplier effect of 1.44. The largest employment and value added impacts would be for restoration sitework (483 job-years, $43.5 million), recreational improvements (224 job-years, $20.2 million), plants and seeds purchased (78 job-years, $8.8 million), and design, engineering, and consultants (56 job-years, $4.9 million), with smaller impacts for planting trees and ground cover (14 job-years, $0.8 million), and motor vehicle purchases (<1 job-year, $0.1 million).

Average annual impacts over the five-year project period are 171 jobs, $15.7 million value added, $0.46 million in state taxes, and $0.34 million in local taxes.

Avoided Operating, Maintenance and Repair Costs. Operating, maintenance, and repair costs for Kirkpatrick Dam, Buckman Locks and canal works were considered as potential avoided cost benefits associated with river restoration. Cost data provided by the Cross Florida Greenway Manager's Office for most years during 2002-19 totaled $8.41 million and averaged $442,817 per year (2024 dollars). In addition, there is a backlog of $4 million in deferred repairs and maintenance on the dam and associated structures, and assuming that this work would be done over a 10-year period. The total avoided cost benefit for elmination of operations and maintenance of the lock and dam complex is estimated to average $842,000 per year.

Benefits of Increased Recreational Use. The benefits of possibly increased recreational use of the Ocklawaha River under restoration were assessed from the 2016-17 survey results on average group spending together with changes in visitation observed during the 2019-20 Rodman Reservoir drawdown period, and expected increased visitation because of recreational improvements. During the 2019-20 drawdown there was a 10.5% increase in overall visitation, including more than 20% increase for reservoir sites. Based on an average of 359,706 visitors during 2017-23, and an average visitor group spending level of $253.40 in 2017 ($317.85 in 2024 dollars), there would be an increase of $12 million in output. The change in visitation during the most recent drawdown is considered the most objective evidence of potential change in recreational usage under restoration. Increased visitation and recreational use of the restored river and reservoir represents improved environmental conditions and enhanced wildlife diversity, such as migratory fish and manatees that would have improved access to the upper portions of the river and Silver Springs, and use of the 20 small springs that were previously submerged under the reservoir, as well as Silver Springs. Note that small springs in north-central Florida generate an economical average output contribution of $1 million to $3 million annually (Borisova et al. 2015). In addition, a 10% increase in visitation at Silver Springs State Park during the past three years (546,523 x 10% = 54,652 individuals) was assumed for recreational improvements at several sites to enable manatee viewing. The increased number of visitors was multiplied against average visitor group spending, adjusted for average party size (2.5 persons), to estimate increased visitor spending of $6.95 million (2024 dollars). Total annual benefits of increased recreational spending because of the drawdown effect and the recreational improvement effect were estimated at $19.80 million starting in the 10th year.

Summary Cost-Benefit Analysis. The information on restoration costs, dam operations costs, and expanded recreational use under restored river conditions were compiled by year over a 20-year planning period, assuming that increased economic output from expanded tourism recreational spending would likely develop over a period of 10 years as wildlife populations recover and native vegetation matures along the riverbanks. Restoration costs were treated as negative cash flows, while dam/lock cost savings and recreational industry output changes are positive values (benefits) in calculating annual net benefits. The net benefits are negative during the first five years, reflecting the large upfront restoration and recreational improvement costs during this period, then net benefits rise to $19.80 million starting in Year 10 (Fig. 4). Total cumulative net benefits over 20 years are estimated at $197.88 million. The benefit-cost ratio for the project is 2.09, meaning that for every dollar of investment $2.09 in net benefits is generated. The cash flows represent an average annual rate of return on investment (ROI) of 5.4%, and an internal rate of return (IRR) of 14.0%. Applying an annual discount factor of 3% to give benefits and costs in net present value (NPV) terms reduces the benefit-cost ratio to 1.32.

Conclusions

This study examined recreational usage of the Ocklawaha River and Rodman Reservoir. Analysis of visitor expenditures showed that activities on the natural stretches of the Ocklawaha River result in greater contributions to the regional economy compared with Rodman Reservoir sites. Both fishing and non-fishing opportunities are important for visitors and provide economic benefits. Previous studies on dam removal in other parts of the U.S. reported significant increases in recreation following river restoration; in this case, however, river restoration would be expected to have a complex effect on recreation, increasing some types of activities such as canoeing and kayaking, but potentially reducing fishing. Recreation at river sites generates greater economic contributions and benefits than reservoir sites in part because of the river. Survey respondents at reservoir sites were more certain about their intended visits following the restoration, with a majority indicating a likely reduction in their visitation. The economic impacts of restoring the river would depend on the extent to which businesses serving the area can adapt to changes in recreation preferences such as increased nonmotorized boating. Fishing visitors may also switch from the reservoir to the river or to other nearby freshwater lakes. To minimize potential negative impacts of breaching the Kirkpatrick Dam on fishing activities in the region, the Ocklawaha restoration plans should focus on expanding and enhancing onshore fishing opportunities along the restored Ocklawaha River and at other sites in the area to ensure that fishing activities continue to serve as an attraction to the region. Additionally, because fishing activities are a draw for low-income local residents, adding fishing decks with access roads along the river could address potential distributional consequences. The study found that nonlocal visitors typically had higher trip expenditures. To attract more nonlocal visitors to a restored river, the restoration effort should enhance river-based recreation opportunities and better inform the public about the restoration outcome and timeline.

Acknowledgments

Portions of this report were adapted from a previous University of Floridasponsored project study report titled "Ocklawaha River: Economic Importance and Public Preferences for Water Resource Management for the Ocklawaha River" (Borisova et al. 2017), and a published journal article (Borisova and Hodges 2019). Study coinvestigators were Tatiana Borisova, Xiang Bi, and Alan Hodges in the Food and Resource Economics Department, and Stephen Holland, Department of Tourism, Recreation, and Sport Management.

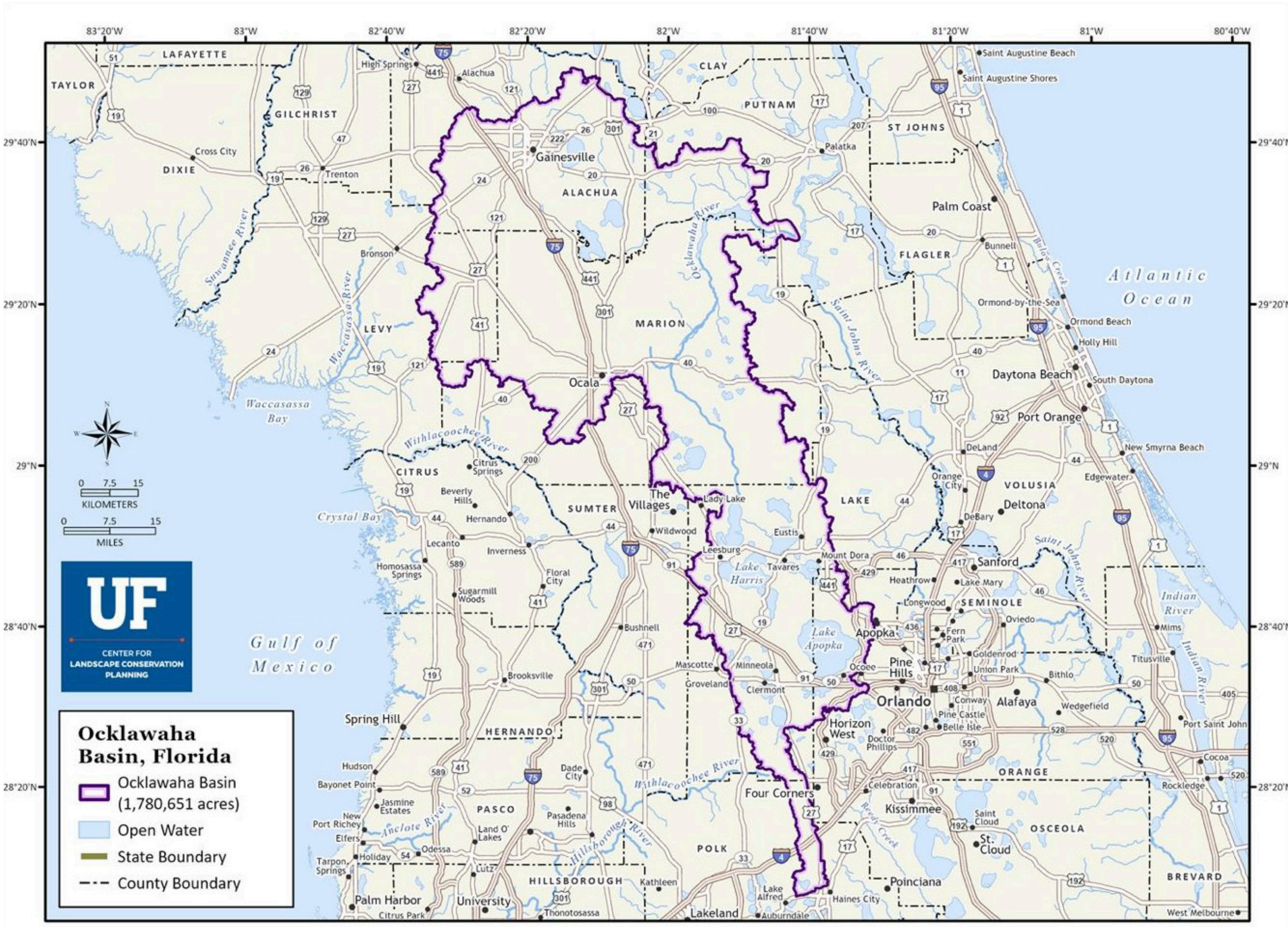


Figure 1. The Ocklawaha Basin.

Global Significance of the Ocklawaha River

The Ocklawaha is one of the most ancient rivers in Florida and one of the few rivers in the nation that flows south to north. The Ocklawaha River drainage basin spans approximately 2,800 square miles, while the river flows 78 miles (Fig. 1). The Ocklawaha is the largest tributary to the longest river in the state, the St. Johns River, and is a major source of freshwater flow into the St. Johns, vital to its 100-mile-long estuary (Bricker et al. 1999).

The Ocklawaha River receives a significant portion of its water from the outpouring of Silver Springs, one of the largest first-magnitude inland springs in the United States. Silver Springs and Rainbow Springs to the west are examples of how Florida ranks as having the most artesian spring resources in the United States and higher than most areas globally (Rosenau et al., 1977). Silver Springs flows into the Silver River, which in turn connects to the Ocklawaha. The Silver River is one of the few wild rivers remaining in the United States. The Ocklawaha, the Silver River, and the St. Johns form a three-part river system that reaches 217 miles from Lake Apopka (headwaters) to the Atlantic Ocean. Their combined watersheds cover a significant portion of the state, approximately 9,500 square miles or 17.5% of Florida's land area (Fig. 2).

The Ocklawaha River is located within a global biodiversity hot spot—an area rich in species diversity. Biodiversity is not distributed randomly or uniformly across the Earth but is concentrated in certain places. Globally, there are 36 biodiversity hot spots recognized (Noss et al. 2015). All hot spots hold two main criteria: They are home to at least 1,500 endemic plant species (as well as many endemic animal species) and they have suffered at least 70% habitat loss. Moreover, Florida ranks fourth nationally in its number of endemic species—species that occur nowhere else on Earth (Stys et al. 2017).

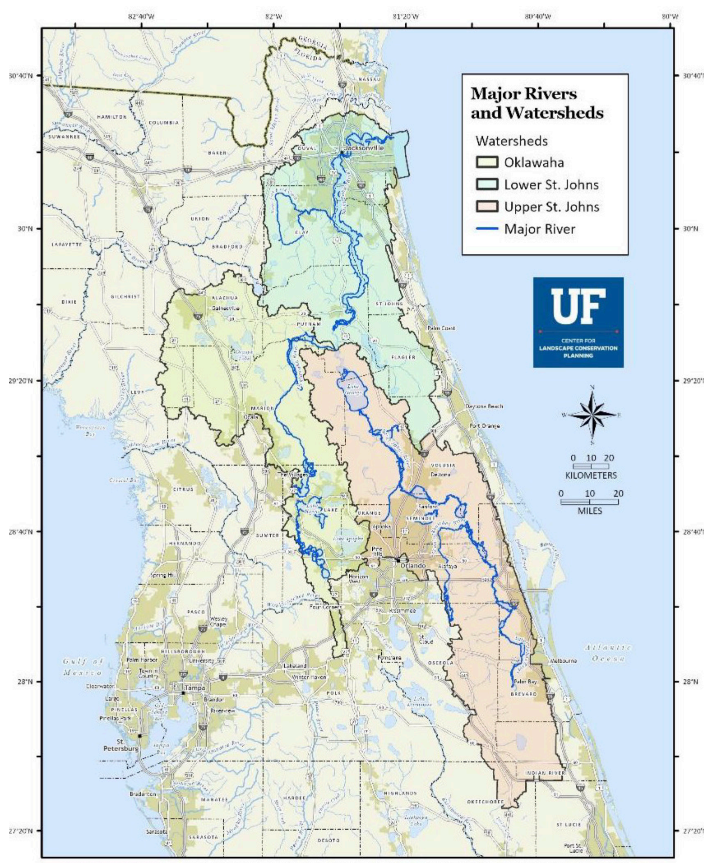
The Ocklawaha River runs adjacent to the Ocala National Forest, a globally significant forest with the only sizable sand pine forest ecosystem on Earth (Sanger 1983). The Ocala National Forest is the southernmost national forest in the continental United States and the oldest national forest east of the Mississippi River. It is also the second largest nationally protected forest in the state after the Apalachicola National Forest in the Panhandle.

The Ocklawaha River Basin's Biodiversity

In 1882, George Barbour described the Ocklawaha River in his guidebook to the state as follows (as cited in Noll 2004):

> The river, as it is termed, is quite an indefinite body of water. It is more properly a series of lagoons, overflowed swamps, long narrow lakes, and great springs—all connected and interlinked—the water basin of the western portion of the St. John's River Valley. It is an extensive region of dense jungle, lying low and flat, undrainable, and impossible to improve for human use; and will always remain wild and unmolested, a paradise for all the strange reptiles, insects, birds, and fish that seek its innermost recesses. To the pleasure-seeking tourist and the sportsman it affords an inexhaustible field of interest, but to the invalid, health seeker, or practical settler it offers no attractions. As the steamer follows the vaguely defined course of the channel, there are frequent landings, localities where points of the mainland extend like a peninsula into this watery jungle, affording access and outlets to the more profitable and healthy regions lying inland all along the route.

The Ocklawaha River Basin is much changed from its primeval condition as described by Barbour. Nevertheless, it still has a rich natural history, considerable wildness (most of the river floodplain is protected in several conservation areas), and is home to high levels of endemism, holding flora and fauna unique to both Florida and the world. The high biodiversity and endemism of the basin can be traced to its geology, geomorphology, climate, and evolutionary history.



11/5/2024. Data: Environmental Systems Research Institute, Florida Fish and Wildlife Conservation Commission, Florida Geographic Data Library, Florida Natural Areas Inventory, University of Florida Center for Landscape Conservation Planning, U.S. Census Bureau, U.S. Geological Survey. Projection: Web Mercator

Figure 2. Major Rivers of the Ocklawaha and St. Johns River Watersheds

Geology and Geomorphology

The Ocklawaha Basin includes portions of two geomorphic districts, or areas of distinct landform types, which are further subdivided into 13 geomorphic provinces (Williams et al. 2022) (Fig. 3). The first of these districts, the Ocala Karst District, is dominated by significant karst landforms such as sinkholes and springs, which are related to the soluble carbonate (limestone) geology. The district includes seven geomorphic provinces within the Ocklawaha Basin: Alachua Karst Hills, Ocala Karst Hills, Brooksville Ridge, Williston Karst Plain, Fairfield Karst Hills, Tsala Apopka Plain, and Green Swamp. The district represents most of the largest expanse of eogenetic karst (landforms whose host rocks are geologically young and have never been deeply buried) in the United States and one of the largest areas of young karst worldwide. Karst-related landforms within the Ocala Karst District include abundant sinkholes, arches, land bridges, springs (Florida has the most first-magnitude springs in the world; Scott et al. 2004), terrestrial and aquatic caves, and other karst features. Some of these features, especially the caves and springs, are home to narrow endemic species of crayfish, shrimp, isopods, and other invertebrates (FNAI 2010). The Ocala Karst District is a major recharge area for the Floridian aquifer, one of the most significant limestone aquifers in the world (Williams et al. 2022).

The Lakes District is the other geomorphic district that overlaps the Ocklawaha River Basin.

Portions of six geomorphic provinces are within the basin: Mount Dora Ridge, Lake Wales Ridge Complex, Fort McCoy Plain, Tavares Lakes, Hawthorne Lakes, and Ocklawaha River valley.

The Lakes District is geomorphically complex with numerous north-to-south trending ridges separated by valleys and lakes, with most of the latter occupying well-defined sinkhole depressions. At 48 square miles, Lake Apopka, part of the headwaters of the Ocklawaha River, is one of the largest lakes in Florida. Many of these large lakes are more or less circular. The district also includes an important segment of the St. Johns River valley and the headwaters of the Peace and Ocklawaha rivers (Williams et al. 2022).

The northern portion of the Lake Wales Ridge Complex Province, which occurs within the Lakes District, is distinguished by a rather abrupt increase in elevation from surrounding lowlands. The Lake Wales Ridge is known for its relatively hilly terrain, deep sands, and abundant sinkholes and sinkhole lakes (Williams et al. 2022). The isolation of much of the Lake Wales Ridge during high sea-level stands at several time periods from the Late Miocene to Pleistocene in Florida led to allopatric speciation (in isolation) of many endemic plants, particularly in scrub habitats. Most of these endemics are older than previously assumed, apparently originating in the Miocene or Pliocene (Germain-Aubrey et al. 2014; Lamb et al. 2017). This is also true to varying extents for the other ancient ridges in Florida, but the Lake Wales Ridge surpasses all of them in its concentration of endemics. The highest elevation in peninsular Florida, 312 feet, occurs on Sugarloaf Mountain in Lake County, near the northern end of the Lake Wales Ridge.

Unfortunately, the Lake Wales Ridge, being high in elevation, xeric and sprinkled with scenic lakes, is also increasingly impacted by population growth and development.

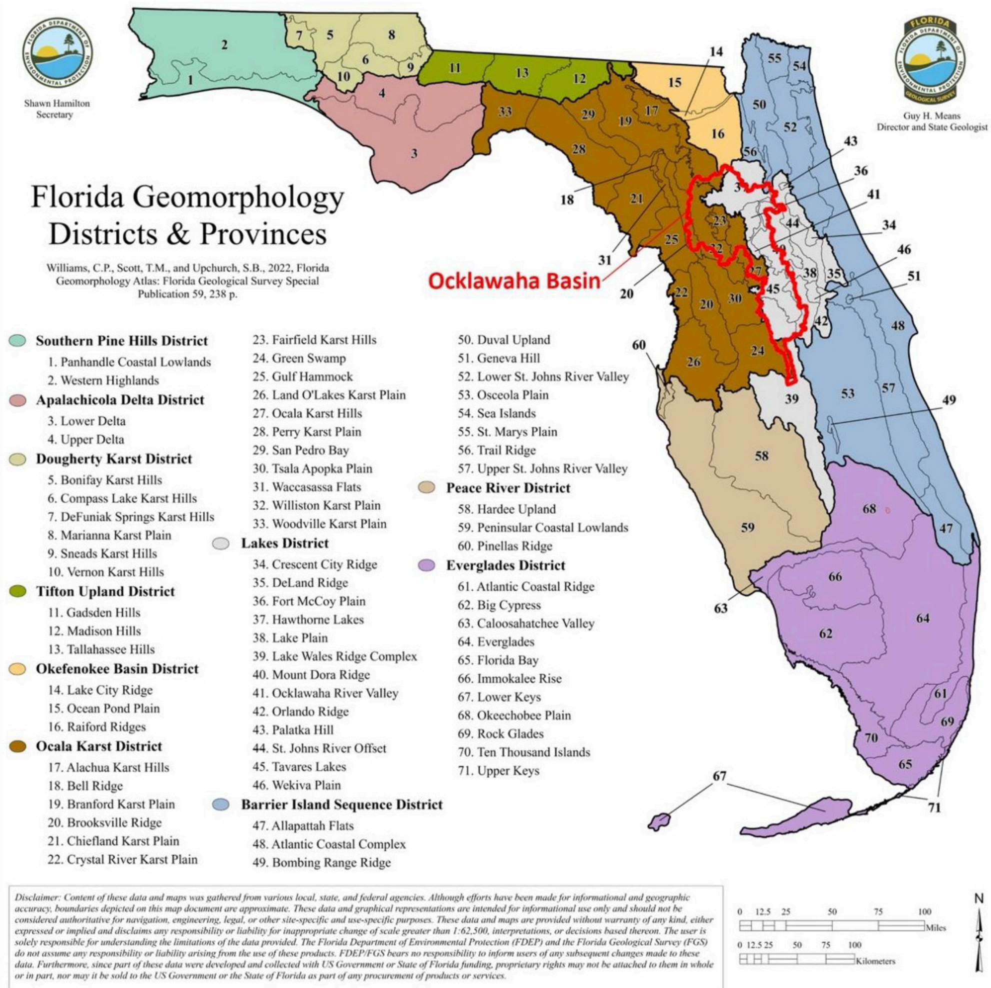


Figure 3. Florida Geomorphology Districts and Provinces, with Ocklawaha basin. From Williams et al. (2022). The Ocklawaha River basin includes portions of the Ocala Karst District and the Lakes District (see text for list of geomorphic provinces within these districts that overlap the basin).

Climate

The climate of the Ocklawaha River basin, according to criteria of the Köppen-Geiger climate classification (Peel et al. 2007), is subhumid subtropical in the southern portion of the basin and humid subtropical in the northern portion of the basin. These climate classes are determined by temperatures of the warmest six months and of the coldest month, and by moisture index (ratio of precipitation and positive temperature average) (BONAP). The average annual rainfall across the region ranges from about 51 to 54 inches. The high temperature in July averages around 90° to 92°F and the low temperature in January averages 44° to 49°F across the region (Bestplaces).

Vegetation and Land Cover

The vegetation of the Ocklawaha basin prior to European settlement was dominated by mesic and wet pine savannas (flatwoods), xeric pinelands (sandhill), various scrub communities, hardwood forests (mesic and hydric hammock), as well as the swamp and bottomland forest of the Ocklawaha River floodplain. Many of these communities have embedded wetlands. The wetlands are chiefly depression marshes and cypress domes in topographic depressions formed from dissolution of underlying limestones, as well as floodplain swamps and other forested wetlands on lake margins and along rivers and streams (FNAI 2010).

The "General Map of Natural Vegetation of Florida" (Davis 1967; Fig. 4) remains the most accurate map of the natural (pre-Euro American settlement) vegetation at a statewide scale, despite its relatively low resolution. As shown in Figure 4, Upland Hardwood Forest was a major historic natural community within the Ocklawaha Basin, which is rare for fire-prone Florida outside of sites topographically protected from fire such as islands, peninsulas, steep ravine slopes, and sinkholes (Harper 1911, Noss 2018). This region is often described as the northern peninsular Hammock Belt and is an area with more fertile soils. The Alachua people, who were of the Ocmulgee culture, entered northern Florida from Georgia around 600 C.E. and took advantage of the relatively fertile soils of the Hammock Belt to support maize agriculture and small chiefdoms (Milanich 1998).

According to the Hernando County Preserves Master Land Management Plan updated in 2021, "the highest-quality map of current land cover in Florida is the Florida Cooperative Land Cover Map version 3.7 (CLC), which was produced from a partnership between the Florida Fish and Wildlife Conservation

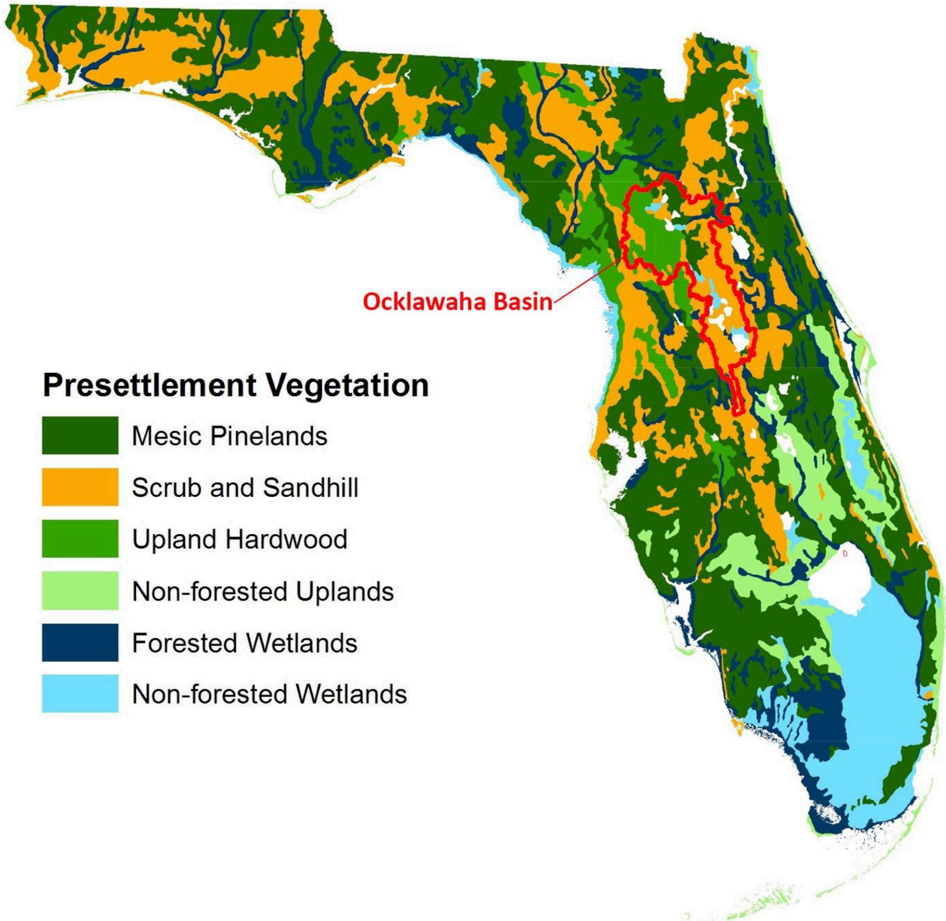


Figure 4. Presettlement vegetation of Florida, with the Ocklawaha basin outlined. From Volk et al. (2017) based on Davis (1967).

Commission (FWC) and the Florida Natural Areas Inventory (FNAI). The CLC map depicts the statewide distribution of both natural communities and altered communities (anthropogenic land cover) developed from existing sources and expert review of aerial photography. The CLC follows the Florida Land Cover Classification System; the latest version of the CLC (2020) can be found at https://myfwc.com/research/gis/regional-projects/cooperativeland-cover/. Figure 5 shows a generalized version of the CLC land cover classes and their distribution across the Basin. Table 1 shows in more detail the acreages and percentages of the 20 most common natural and anthropogenic land cover classes within the Ocklawaha basin" (Hernando County 2021).

Considering the more detailed complete CLC classes (Table 1), the two most abundant current land cover types are coniferous plantations (11.1% of the basin) and improved pasture (9.8% of the basin). Both of these "working lands" types have value for wildlife and biodiversity, with the value typically inversely proportional to the intensity of management. For example, a coniferous plantation with a more open canopy and largely native ground cover has greater conservation value than a mechanically site-prepared plantation with little or no native ground cover.

Improved pasture, while mostly anthropogenic, has conservation value because it is a preferred habitat for several bird species of conservation concern, including three that are federally designated as threatened: the crested caracara (Caracara plancus), the Florida burrowing owl (Athene cunicularia floridana), and the Florida sandhill crane (Antigone canadensis pratensis). These birds hypothetically prefer actively grazed pastures over native grassland because they coevolved with large herbivores during the Pleistocene or earlier and find foraging easier in short-cropped turf (Noss 2013). Nevertheless, a pasture of the poorly defined "semi-improved" type (not in the CLC classification) usually has not been plowed or disked and has a mix of native grasses and nonnative forage grasses and may be of higher value to these birds and other wildlife. Pasture and ranchlands can also be a functional part of habitat mosaics and wildlife corridors.

Of the natural communities In Table 1, mixed hardwood-coniferous is most abundant (8.1%), followed by lacustrine (7.2%), which is open lentic (still) water, and then sand pine scrub (5.5%). Unfortunately, transportation (roads and associated infrastructure) is the next most abundant cover type at 4.9% of the basin, posing multiple threats to wildlife and highlighting the need for wildlife crossing structures and other mitigation. The Ocklawaha River itself represents a significant mosaic of natural communities including broad forested floodplains of swamp and bottomland mixed forest, hydric and mesic hammocks, pine flatwoods, longleaf pine sandhills, and Florida scrub. Collectively these natural communities along the Ocklawaha River provide significant habitat for a variety of aquatic, wetland, and upland focal species found in a

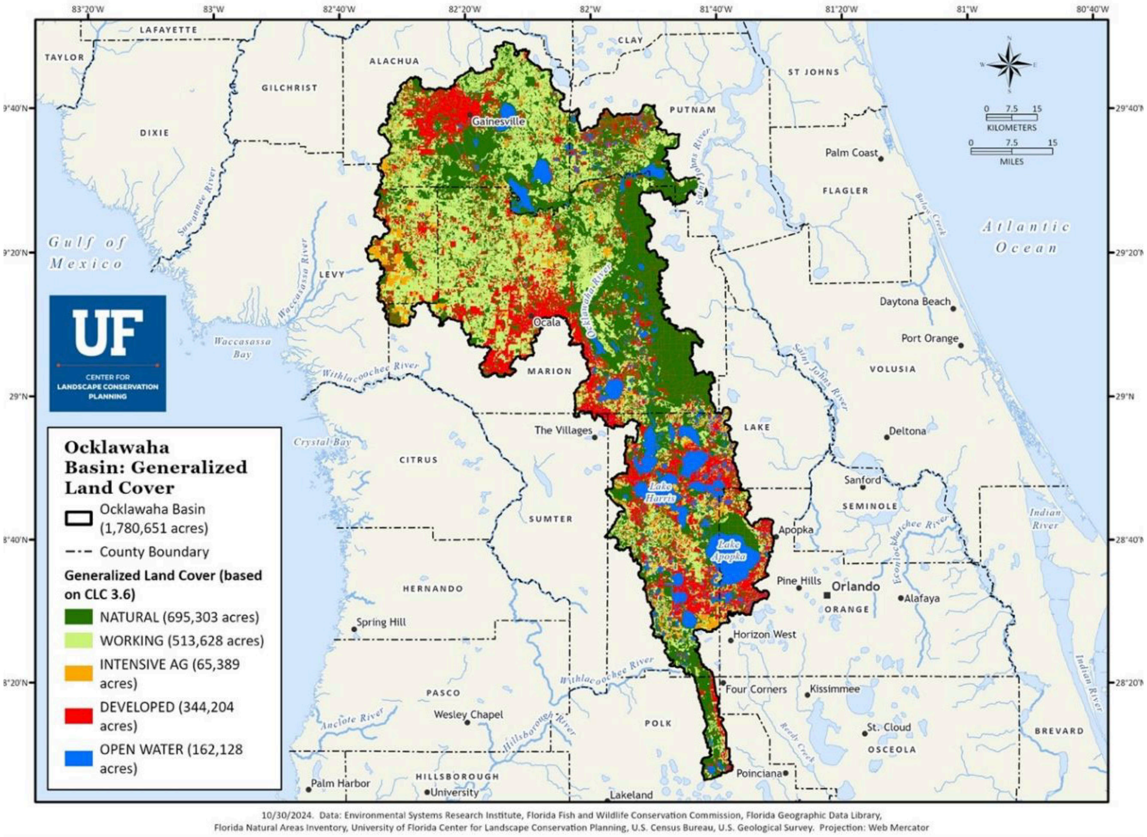


Figure 5. Current land cover (generalized) of the Ocklawaha basin. As shown in light green, "working lands" comprise commercial timberlands mostly in the northern portion of the basin, abundant improved (including semi-improved) pastures grazed by livestock, and developed (mostly urban) land. Together, these land cover classes cover 857,832 acres (> 48%) of the 1.78 million acres of land cover in the region. Natural land covers 695,303 acres (39%) of the region, whereas open water covers 162,000 acres (9%), and intensive agriculture 65,389 acres (4%).

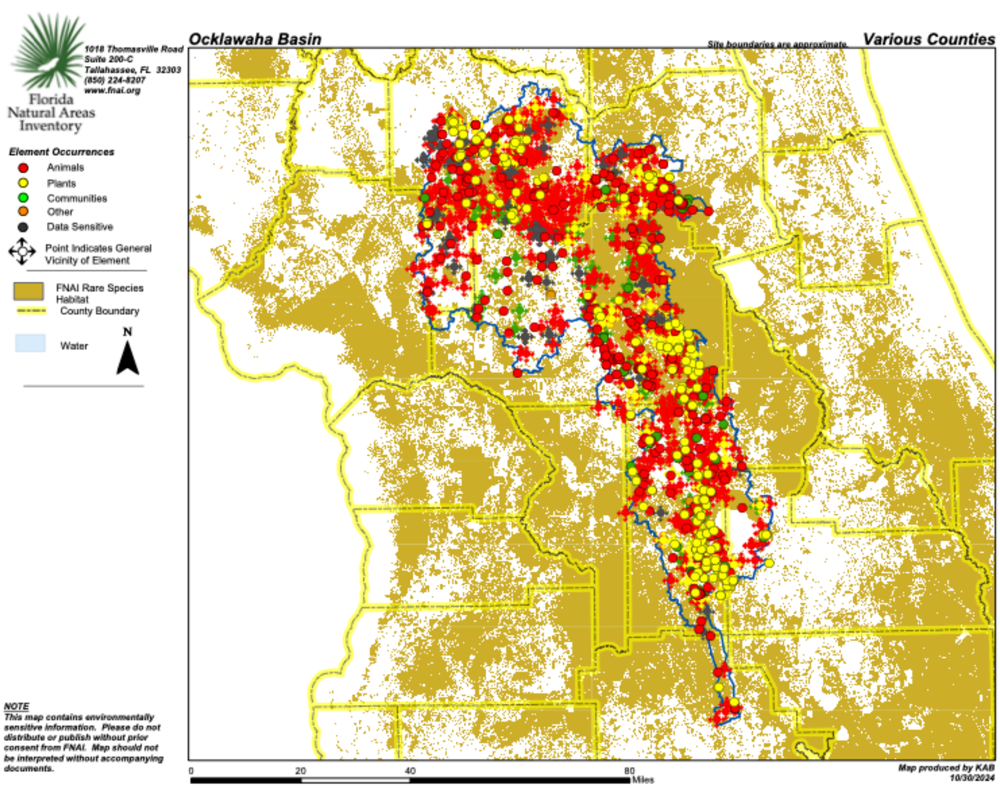


Figure 6. Element occurrences (EOs) of rare species and natural communities tracked by the Florida Natural Areas Inventory (FNAI). Note that EOs are widely distributed across the region but are less concentrated in areas dominated by working lands and urban land cover (as shown in Fig. 3). Data courtesy of FNAI.

combination of broad floodplain forests surrounded by upland pine and scrub. These gradients occurred along almost the entire length of the river, at least prior to the construction of Rodman Reservoir, which destroyed thousands of acres of floodplain forests and some adjacent uplands to fragment the once continuous forested floodplain system that ran from the Ocklawaha River headwaters to the Ocklawaha's mouth at the St. Johns River near Welaka.

Species of Conservation Concern

The Florida Natural Areas Inventory (FNAI) tracks all species of conservation concern with occurrence records in the Ocklawaha basin (Fig. 6, Table 2), as it does statewide. These species, by virtue of their rarity or sensitivity to human activity, warrant special attention in conservation plans. Although the coarse filter of natural community conservation can usually be assumed to meet the needs of most species, rare and sensitive species often need individual attention beyond that of protecting the natural communities with which they are associated. The imperiled species (as well as natural communities) mapped in Figure 6 (with the globally imperiled and critically imperiled taxa listed in Table 2) represent many taxa at risk of extinction and demonstrate the extremely high biodiversity of the Ocklawaha basin and the irreplaceability of the region for conservation. Put another way, the Ocklawaha basin has much more to lose than most regions if development and other human activities are not controlled to minimize risks to rare species.

Table 1. The 20 most abundant "land" (including open water) cover classes in the Ocklawaha Basin and their acreage and percentage of total land cover in the basin.

Land Cover Class	Acres in Basin	Percent of Basin
Coniferous plantations	197,442	11.1
Improved pasture	174,217	9.8
Mixed hardwood-coniferous	143,504	8.1
Lacustrine	128,893	7.2
Sand pine scrub	97,072	5.5
Transportation	87,155	4.9
Residential, low density	85,617	4.8
Marshes	67,763	3.8
Residential, med. density, 2-5 dwelling units/acre	60,333	3.4
Specialty farms	58,499	3.3
Sandhill	54,044	3.0
Mixed wetland hardwoods	42,068	2.4
Rural open	39,909	2.2
Mixed scrub-shrub wetland	33,164	1.9
Mixed hardwood-coniferous swamps	32,923	1.8
Mesic flatwoods	30,276	1.7
Field crops	27,795	1.6
Wet prairie	25,833	1.5
Unimproved/woodland pasture	23,054	1.3
Floodplain swamp	20,604	1.2

The Florida Ecological Greenways Network

On a state scale, one of the clearest ways to highlight the importance of the Ocklawaha River is to look at its position within the Florida Ecological Greenways Network. Florida is a global leader in the science of landscape-scale conservation science and planning to address biodiversity and ecosystem services protection. This planning largely depends on corridor conservation, and the Florida Ecological Greenways Network (FEGN), part of Florida state law since 1997, is the foundational component of this protection strategy. The FEGN is the ecological component of the Florida Greenways Plan administered by the Office of Greenways and Trails (OGT) within the Florida Department of Environmental Protection (Florida Statute §260. 2023).

The FEGN combines the principles of conservation biology and landscape ecology to prevent species loss and the degradation of essential natural resources for the state. This includes protecting natural communities and habitats necessary for viable Florida black bear and Florida panther populations, as well as many other species sensitive to habitat loss and fragmentation.

The FEGN also incorporates important lands for sustaining ecosystem services, such as storm buffering, water storage, and climate resilience. It identifies key opportunities across Florida to integrate large, intact conservation lands into a functionally connected statewide network. The FEGN is also the primary data layer informing Florida Forever and other state and regional land acquisition programs.

The strong science foundation of the FEGN began in 1995 and has been updated, streamlined, and clarified over the past 30 years (CLCP 2021). The most recent update to the FEGN was completed in June 2021 and brought together a technical advisory group (TAG) of over 30 science advisers. The advisory group included state, federal, regional, and nongovernment organizations that vet the model to ensure sure it reflects the most current scientific understandings and the best available data and holds practical conservation applications. FEGN combines over two dozen layers of original spatial data (digital maps), that delineate conservation priorities for biodiversity, essential water resources, and landscapes-scale functions from ecological connectivity to flood storage, water filtration, and carbon sequestration. It pulls in data from the Florida Natural Areas Inventory (FNAI), the Florida Fish and Wildlife Conservation Commission (FWC), the Florida Geographic Data Library (FGDL), and the Florida Department of Environmental Protection (FDEP), as well as data from the Florida Critical Lands and Waters Identification Project (CLIP) and the Florida Forever Needs Assessment (Oetting et al. 2016). Existing conservation lands and additional sources on ecologically significant areas across the state are also incorporated (Hoctor et al. 2024 forthcoming).

The Florida Wildlife Corridor

A five-tiered prioritization ranking guides strategic planning, focusing efforts on the most irreplaceable and vulnerable areas of the FEGN, as well as those areas most crucial for protecting a functionally linked system of public and private conservation lands across the state (Fig. 7).

Table 2. Species of highest conservation concern in the Ocklawaha basin tracked by the Florida Natural Areas Inventory (FNAI). The list below was compiled from a spreadsheet of 1,861 individual element occurrence records for the basin. Because of the wealth of tracked species in the planning region, only the rarest or most imperiled species are listed below: critically imperiled (1), imperiled (2), or historic (H) at a global (G1, G2) scale, including subspecies and varieties (designated by T). Data courtesy of FNAI.

Scientific Name	Common Name	FNAI Global Rank	FNAI State Rank
Animals			
Invertebrates			
Elliptio monroensis	St. Johns elephantear	G1G2	S1S2
Aphaostracon chalarogyrus	Freemouth hydrobe snail	G1	S1
Amnicola rhombostoma	Squaremouth Amnicola snail	GH	SH
Dexteria floridana	Florida fairy shrimp	GH	SH
Floridobolus orini	Orin's scrub millipede	G1G2	S1S2
Hogna ericeticola	Rosemary wolf spider	G1	S1
Geolycosa xera	McCrone's burrowing wolf spider	G2G3	S2S3
Osmia calaminthae	Blue calamintha bee	G1	S1
Stelis ater	Southwest Florida Stelis bee	G2	S2
Nemopalpus nearcticus	Sugarfoot moth fly	G2	S2
Eutrichota gopher	Gopher tortoise burrow fly	G2	S2S3
Libellula jesseana	Purple skimmer	G1G2	S1S2
Oecetis parva	Little Oecetis long-horned caddisfly	G2	S2
Hydroptila Wakulla	Wakulla Springs varicolored microcaddisfly	G2	S2
Melanoplus nanciae	Ocala claw-cercus grasshopper	G1?	S1?
Dasymutilla archboldi	Lake Wales Ridge velvet ant	G2G3	S2S3
Libellula jesseana	Purple skimmer	G1G2	S1S2
Oecetis parva	Little Oecetis long-horned caddisfly	G2	S2
Hydroptila Wakulla	Wakulla Springs varicolored microcaddisfly	G2	S2
Melanoplus nanciae	Ocala claw-cercus grasshopper	G1?	S1?
Dasymutilla archboldi	Lake Wales Ridge velvet ant	G2G3	S2S3
Romulus globosus	Round-necked Romulus long-horned beetle	G1G2	S1S2
Typocerus fulvocinctus	Yellow-banded Typocerus long-horned beetle	G2G3	S2S3
Selonodon floridensis	Florida cebrionid beetle	G2G4	S2S4
Selonodon mandibularis	Large-jawed cebrionid beetle	G2G4	S2S4
Ceratocanthus aeneus	Shining ball scarab beetle	G2G3	S2
Geopsammodius morrisi	Morris's tiny sand-loving scarab	G1	S1
Geopsammodius relictillus	Relictual tiny sand-loving scarab	G2G3	S2S3
Anomala exigua	Pygmy Anomala scarab beetle	G1	S1
Peltotrupes youngi	Ocala deepdigger scarab beetle	G2	S2
Phyllophaga okeechobea	Diurnal scrub june beetle	G1G2	S1S2
Phyllophaga Clemens	Clemens's june beetle	G2	S1
Phyllophaga skelleyi	Skelley's june beetle	G2	S2
Serica frosti	Frost's silky june beetle	G1?	S1?
Ischyrus dunedinensis	Three spotted pleasing fungus beetle	G2G3	S2S3
Triplax alachuae	Alachua pleasing fungus beetle	G2G4	S2S4
Aphodius troglodytes	Gopher tortoise Aphodius beetle	G2G3	S2
Aphodius platypleurus	Broad-sided pocket gopher Aphodius beetle	G2G3	S2
Aphodius tanytarsus	Long-clawed pocket gopher Aphodius beetle	G2G3	S2S3

Scientific Name	Common Name	FNAI Global Rank	FNAI State Rank
Animals			
Invertebrates			
Copris gopher	Gopher tortoise Copris beetle	G2	S2
Onthophagus polyphemi polyphemid	Punctate gopher tortoise Onthophagus beetle	G2G3T2T3	S2
Acrolophus pholeter	Gopher tortoise Acrolophus moth	G1	S1
Idia gopher	Gopher tortoise Noctuid moth	G2G3	S2S3
Vertebrates			
Lithobates capito	Gopher frog	G2G3	S3
Ambystoma cingulatum	Frosted flatwoods	salamander	G2 S1
Notophthalmus perstriatus	Striped newt	G2G3	S2
Sceloporus woodi	Florida scrub lizard	G2G3	S2S3
Heterodon simus	Southern hognose snake	G2	S2S3
Grus americana	Whooping crane	G1	S1
Antigone canadensis pratensis	Florida sandhill crane	G5T2	S2
Aphelocoma coerulescens	Florida scrub jay	G1G2	S1S2
Neofiber alleni	Round-tailed muskrat	G2	S2
Plants			
Asplenium heteroresiliens	Morzenti's spleenwort	G2	S1
Asplenium plenum	Ruffled spleenwort	G1Q	S1
Digitaria gracillima	Longleaf fingergrass	G1	S1
Schizachyrium niveum	Scrub bluestem	G1G2	S1S2
Ctenium floridanum	Florida toothache grass	G2	S2
Polygala lewtonii	Lewton's Polygala	G2	S2
Centrosema arenicola	Sand butterfly pea	G2Q	S2
Clitoria frgrans	Scrub pigeon-wing	G2G3	S2S3
Warea amplexifolia	Clasping Warea	G1	S1
Warea carteri	Carter's Warea	G1	S1
Salix floridana	Florida willow	G2G3	S2S3
Dicerandra cornutissima	Longspurred mint	G2	S2
Monotropsis reynoldsiae	Pygmy pipes	G2	S2
Orbexilum virgatum	Pineland scurfpea	G1	S1
Matelea floridana	Florida spiny-pod	G2	S2
Lythrum curtissii	Curtiss's loosestrife	G2	S2
Verbesina heterophylla	Variable-leaf crownbeard	G2	S2
Chionanthus pygmaeus	Pygmy fringe tree	G2G3	S2S3
Calopogon multiflorus	Many-flowered grass-pink	G2G3	S2S3
Spiranthes floridana	Florida ladies'-tresses	G1	S1
Spigelia loganioides	Pinkroot	G2	S2
Sideroxylon alachuense	Silver buckthorn	G1	S1
Forestiera godfreyi	Godfrey's swampprivet	G2	S2
Agalinis georgiana	Pine barren false foxglove	G1	S1

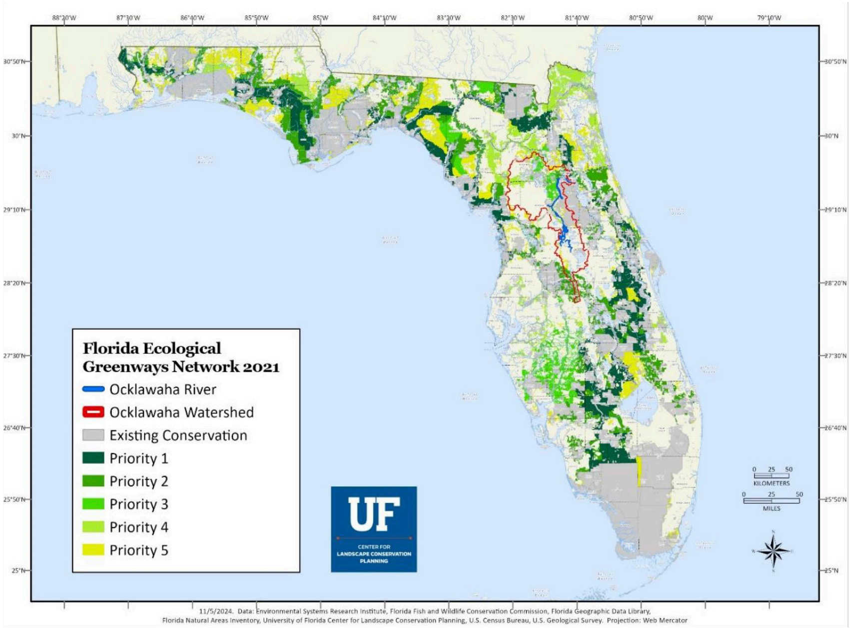


Figure 7. The Florida Ecological Greenways Network

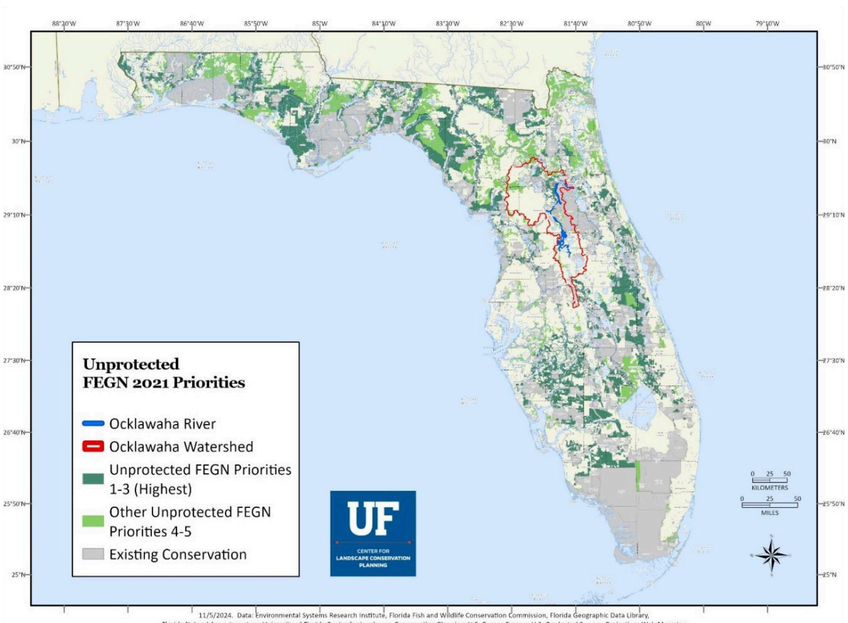


Figure 8. Unprotected Priorities of the Florida Ecological Greenways Network

Table 3. Comparison of the number and percentages of acres for each of the priority areas across the above-mentioned CLIP resource categories within the Ocklawaha River watershed.

Statewide Priority Level	CLIP 4.0 Biodiversity Resource Acres	Percent in Ocklawaha Watershed	CLIP 4.0 Land-Scape Resource Acres	Percent in Ocklawaha Watershed	CLIP 4.0 Surface Water Resource Acres	Percent in Ocklawaha Watershed	CLIP 4.0 Groundwater Resource Acres	Percent in Ocklawaha Watershed
P1	194,890	10.9%	210,314	11.8%	128,826	7.2%	219,955	12.4%
P2	303,400	17.0%	13,006	0.7%	258,326	14.5%	366,509	20.6%
P3	347,903	19.5%	399,522	22.4%	91,285	5.1%	544,770	30.6%
P4	331,611	18.6%	318,174	17.9%	390,846	21.9%	338,112	19.0%
P5	114,238	6.4%	53,207	3.0%	686,380	38.5%	194,158	10.9%
P6	-	-	-	-	-	-	5,398	0.3%
No Value Identified	488,613	27.4%	786,431	44.2%	224,992	12.6%	111,753	6.3%

Priority 1 areas are called “critical linkages.” The Florida Wildlife Corridor contains the top three priority levels of the FEGN. In July 2021, Governor Ron DeSantis signed the Florida Wildlife Corridor Act into law (Florida Statute §259.1055. 2021). It passed with rare bipartisan support. The act has increased support for corridor protections, incentivized voluntary conservation participation, and bolstered the shared vision and goals of this network throughout Florida.

Ocklawaha River Basin Ecological Significance Based on CLIP Data

The Ocklawaha River’s importance on a regional to state scale is highlighted in several components of the Critical Lands and Waters Identification Project (CLIP). CLIP is a multiinstitutional expert science database created by researchers from the University of Florida Center for Landscape Conservation Planning, the Florida Natural Areas Inventory (FNAI), and the Florida Fish and Wildlife Conservation Commission (FWC). It identifies and prioritizes areas of focus for several statewide conservation efforts. The CLIP maps clearly illustrate the importance of the Ocklawaha River in addressing regional and state conservation needs and goals, including long-range planning decisions.

CLIP is organized into resource categories, each containing core natural resource data layers made up of multiple prioritized components. Within the Ocklawaha River watershed, these key resource categories—biodiversity, surface water, groundwater, and landscape resources—highlight areas of statewide importance.

The CLIP Biodiversity Resource Category (Fig. 9) is made up of four core data layers—strategic habitat conservation areas, potential habitat richness, rare species habitat conservation priorities, and priority natural communities. Shown in dark green, sections of the Ocklawaha River Basin, especially to the east, are the highest priority in statewide biodiversity conservation.

Composite layers for this resource category all show a similar pattern to Priority One (Fig. 10 to 13). This region contains high concentrations of critical habitat for many sensitive native species throughout thousands of acres of riverine swamps, floodplain forests, and essential upland habitats. This includes rare, underrepresented xeric natural communities (sandhill, scrub, and scrubby flatwoods), as well as upland and mesic longleaf pine forests, discussed in the previous section.

The surface water resource category (Fig. 14) also highlights the Ocklawaha River watershed as an area of statewide conservation priority. This composite layer is made up of significant surface waters, natural floodplains, and wetlands. Areas in dark blue are of highest priority statewide.

The resource category of groundwater represents areas important for statewide aquifer recharge. Again, the darker the area, the higher it is in statewide significance (Fig. 15).

Finally, the CLIP Landscape Resource Category contains the Florida Ecological Greenways Network as well as the Landscape Integrity Index, which identifies the areas in the state with the most intact natural systems in larger areas with low habitat fragmentation. This data layer highlights the importance of the Ocklawaha River watershed in protecting large areas of intact natural and seminatural lands statewide, as well as the critical component of ecological connectivity across natural and rural landscapes statewide (Fig. 16).

Ocklawaha Watershed and Floodplain - Biodiversity Resource Priorities

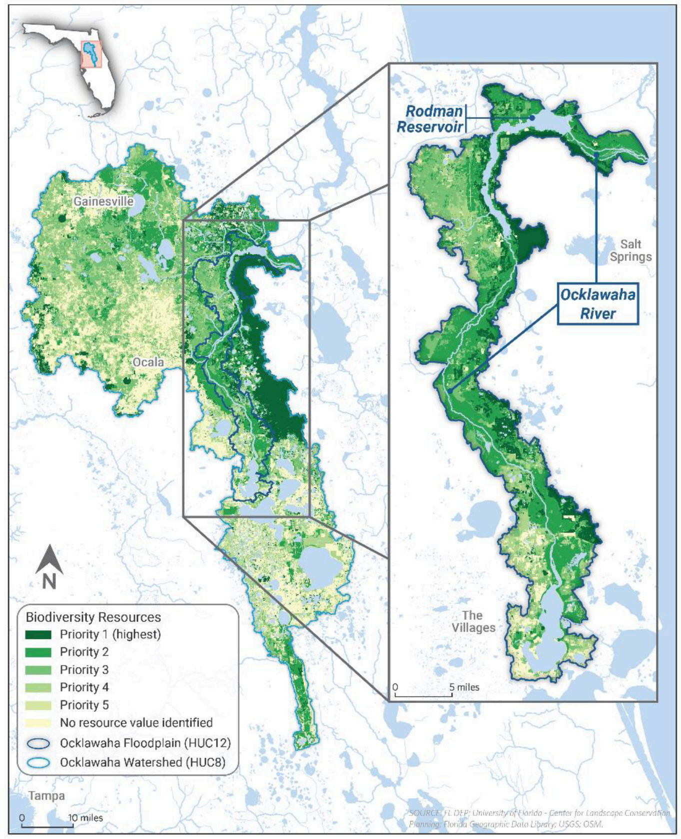


Figure 9. CLIP 4.0 Biodiversity Resource Priorities for the Ocklawaha River Watershed

Ocklawaha Watershed and Floodplain - Strategic Habitat Conservation Areas

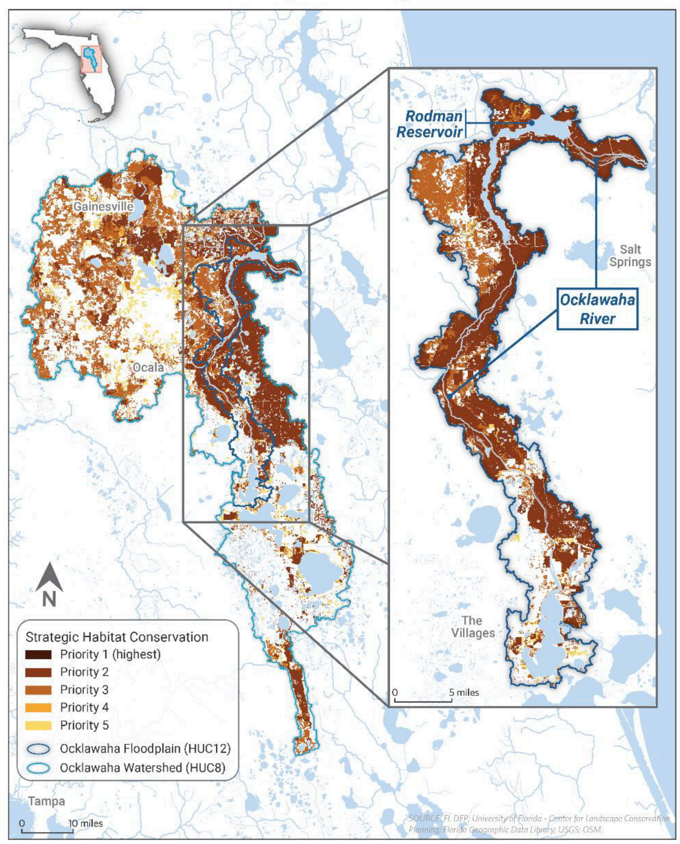


Figure 10. CLIP 4.0 Strategic Habitat Conservation Areas for the Ocklawaha River Watershed

Ocklawaha Watershed and Floodplain - Priority Natural Communities

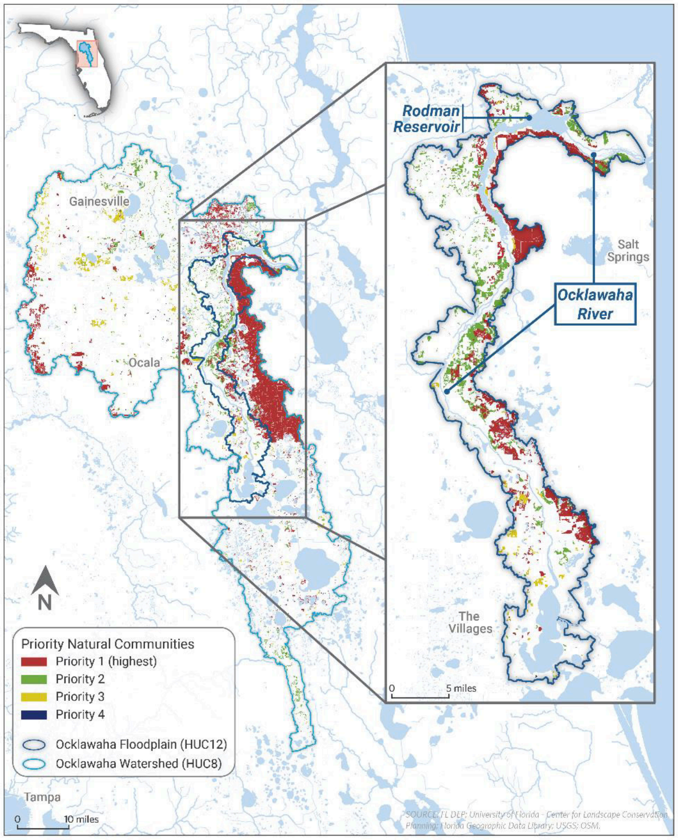


Figure 11. CLIP 4.0 Priority Natural Communities for the Ocklawaha River Watershed

Ocklawaha Watershed and Floodplain - Rare Species Habitat Conservation

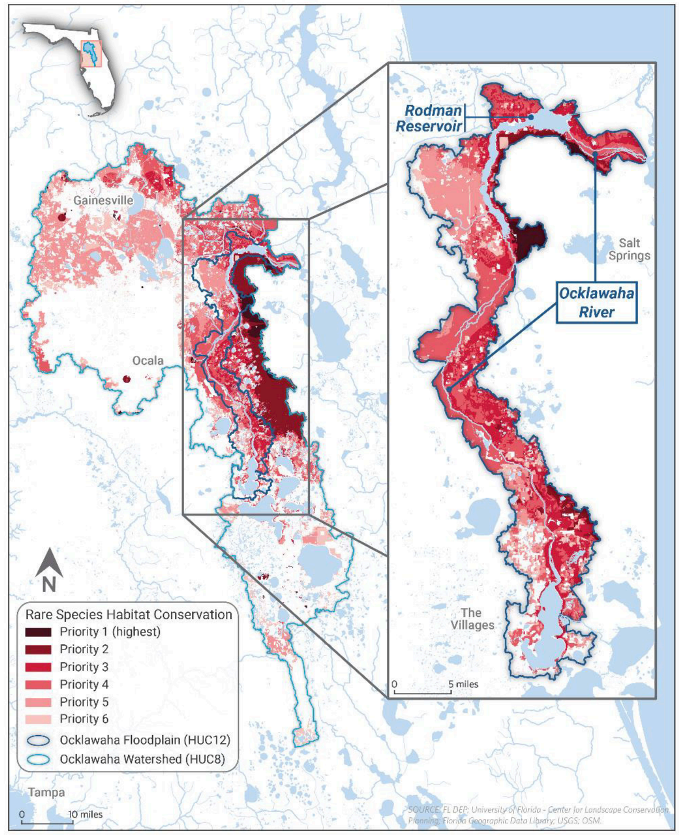


Figure 13. CLIP 4.0 Rare Species Habitat Conservation for the Ocklawaha River Watershed

Ocklawaha Watershed and Floodplain - Potential Vertebrate Habitat Richness

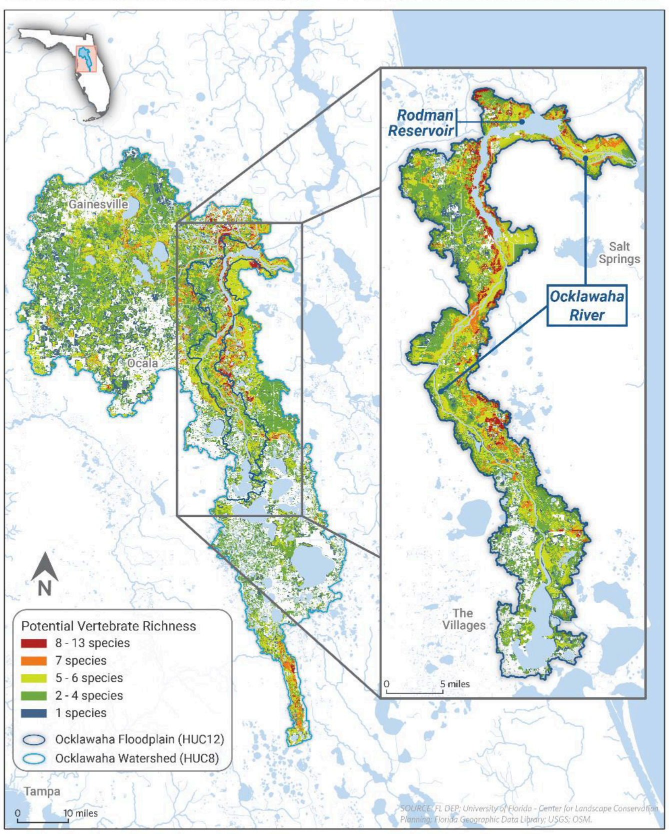


Figure 12. CLIP 4.0 Potential Vertebrate Habitat Richness for the Ocklawaha River Watershed

Ocklawaha Watershed and Floodplain - Surface Water Resources

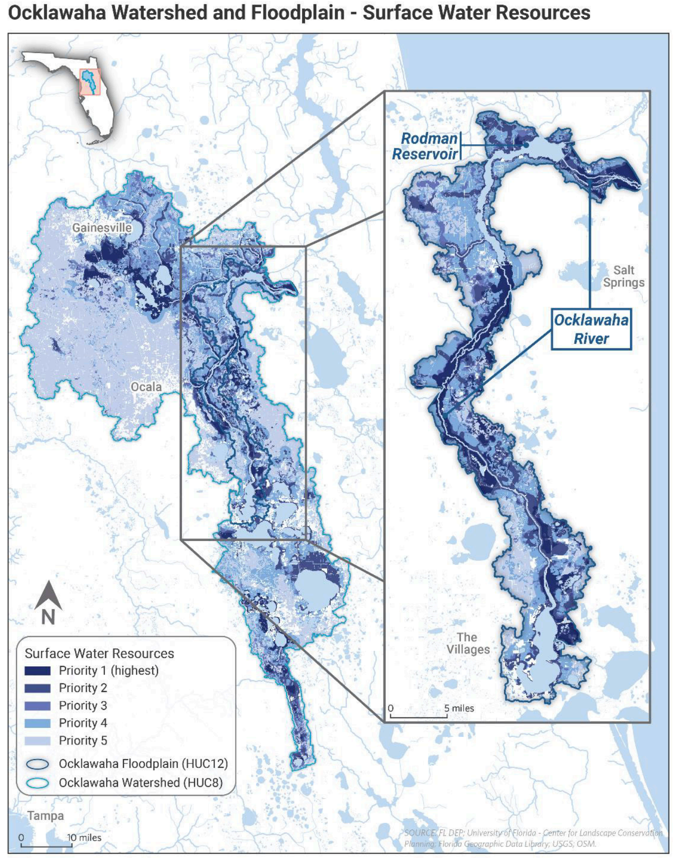


Figure 14. CLIP 4.0 Surface Water Resource Priorities for the Ocklawaha River Watershed

The Ocklawaha River as Wildlife Habitat and Corridor

The entire Ocklawaha River is also part of the Florida Ecological Greenways Network and almost completely within the Florida Wildlife Corridor (Fig. 7). As stated above, river restoration would play a significant role in facilitating functional connectivity with the O2O corridor. In addition, the river and its forested floodplain are extremely important intrinsically. At the landscape scale they provide important and rare habitat that facilitates focal species' movement along an intact hydrological connection from the Green Swamp, Palatlakaha River, and Harris Chain of Lakes, down the Ocklawaha River, and into the St. Johns River.

Though the wildlife corridor value of the Palatlakaha River is in doubt because of encroaching development, much of this hydrologic system is represented in the Florida Ecological Greenways Network. At the very least, from a landscape perspective, the Ocklawaha River provides a "wildlife highway" all the way from the north end of the Harris Chain of Lakes to the floodplain on the St. Johns River downstream from Lake George.

The Ocklawaha River represents a mostly protected, large, forested floodplain system that is currently only interrupted from its start to its mouth at the St. Johns River by the flooded open water and marsh of Rodman Reservoir. In addition, the Ocklawaha River floodplain is also often still surrounded by intact upland forested habitats in unique and often swift and steep gradients ranging from floodplain forests to mesic hammocks, xeric hammock, pine flatwoods, sandhills, and scrubs. These intact gradients provide now rare opportunities to provide functional interactions between flooding and (prescribed) fire. These habitat gradients are extremely diverse and provide habitat for a wide variety of Florida listed and other focal species. These intact aquatic-wetland-upland habitat gradients also provide prime habitat facilitating seasonal shifts in habitat use and for species to better respond to drought, floods, and climate change. Restoring the Ocklawaha River would significantly enhance these habitat and corridor values of the river floodplain by reconnecting a forested floodplain from the start of the river all the way to the St. Johns River.

Ocklawaha Watershed and Floodplain - Groundwater Resource Priority

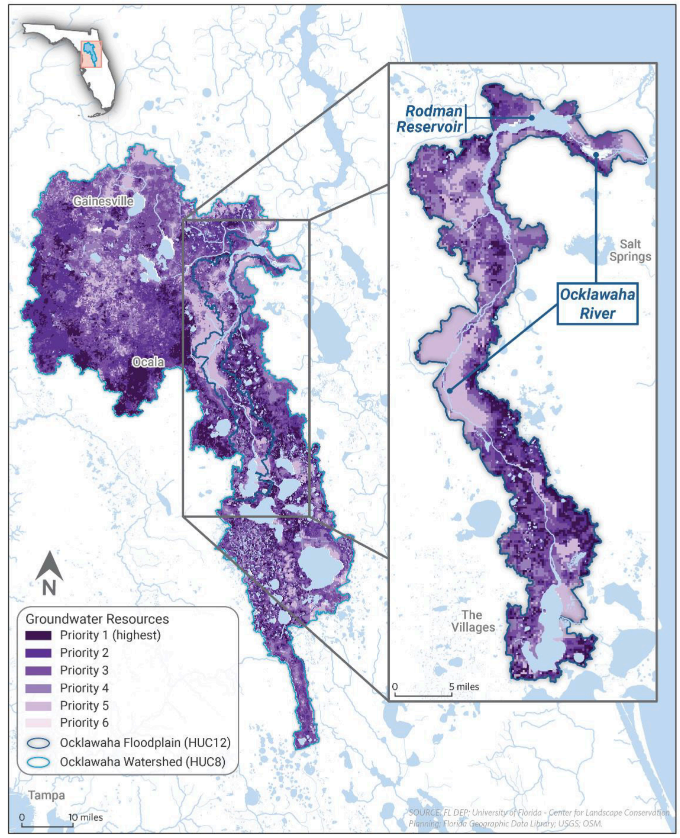


Figure 15. CLIP 4. Groundwater Resource Priorities for the Ocklawaha River Watershed

Ocklawaha Watershed and Floodplain - Landscape Resource Priorities

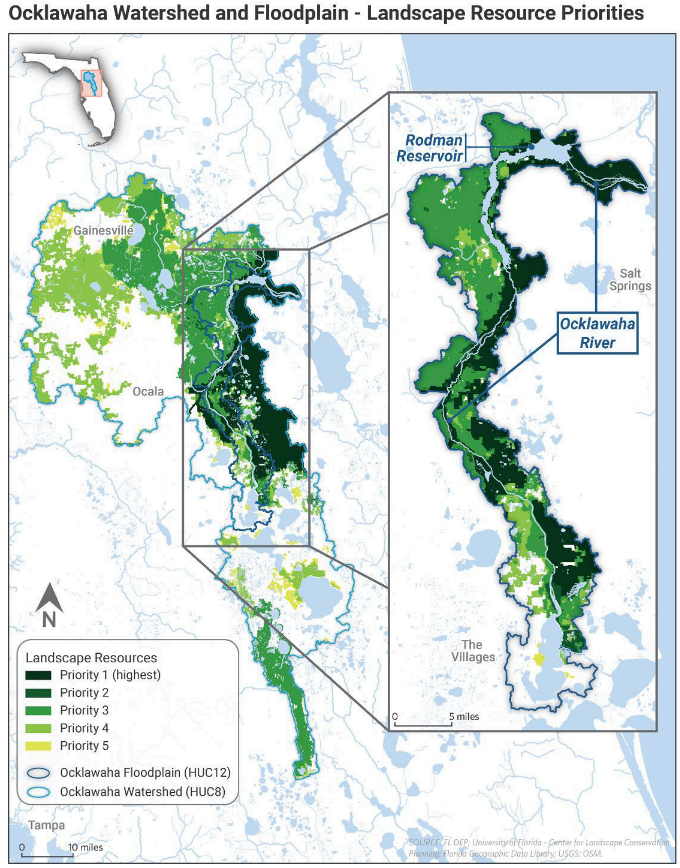


Figure 16. CLIP 4. Landscape Resource Priorities for the Ocklawaha River Watershed

ECONOMIC VALUATION OF PROPERTIES AT RISK
Identified in the Emergency Action Plan, Kirkpatrick Dam and Rodman Reservoir, 2007

Analysis by Michael Spontak, GIS Analyst, June 2020

In the 2018 Marjorie Harris Carr Cross Florida Greenway Plan, the document mentions, "Approximately 400 plus properties were shown to be in potential harm's way if the Kirkpatrick Dam failed and the impounded water in the reservoir flowed downstream in an uncontrolled discharge."

The 400 plus properties number was most likely derived from the 2007 document: *Emergency Action Plan, Kirkpatrick Dam and Rodman Reservoir (EAP, Feb. 2007).* The maps contained in this document were georeferenced by a GIS analyst, tracing the flood outline and clipping the parcels out from a current database. The number of parcels shown to be in that area based on 2018 Putnam County Property Appraiser data is 538 parcels with 11,142 acres potentially flooded. Parcels in that area have been subdivided since the 2007 EAP and the georeferencing approach may have pulled in partial parcels, as well. The recent analysis contains the 2018 value of public lands, as well as privately-owned parcels.

	Total Acres	Acres Outside Floodplain	# of Parcels	Value
Private	2,498.16		482	$9,410,650
Public	19,922.84		57	$47,973,792
Total	22,421.00	11,142.45	539	$57,384,442

The analysis included ACRES (the original parcel area), ACRESFLOOD (acres within the flood area) and PCT_FLOOD (percent of property flooded). The GIS analyst multiplied JV (just value) by percent flooded (JV x PCT_FLOOD) to get an estimate of potential economic loss. The prorated value of the properties to be potentially affected is approximately $57,384,442. A copy of the full database and PDF explaining the metadata and the different fields is available. Other potentially useful fields in the full database include county location, owner location, land value, improvements value, sales prices, number of buildings, residential units, etc.

Other Economic Risks with Dam Failure:
An unplanned release of water and sediment from the dam could result in damage to downstream waters including the 100-mile St. Johns River Estuary. The Estuary, running through Clay, Duval, Flagler, Putnam, and St. Johns Counties, reported an annual total commercial crab harvest of 1.5 million pounds and a fish harvest 278,000 pounds in 2017 (St. Johns State of the River Report, Jacksonville University).

In addition, a Rodman Dam failure could potentially damage the existing roadway over the dam and cut off one point of access for the community to the west of the dam.

APPENDIX E.
METHODOLOGY

Literature Review

The project team engaged subject matter experts to evaluate existing literature relating to the restoration of the Ocklawaha River and related topics. Reference material was limited to highquality, reliable sources, including, but not limited to, peer-reviewed journal papers, government reports, policy documents and other science-based publications.

Economic Analysis

Methodology for the economic assessment of Ocklawaha River restoration is available in Appendix B. The full Economic Assessment of Ocklawaha River Restoration Report is available by request.

GIS Methodology - CLCP Section

Florida Panther and Black Bear Connectivity Data

Data discussed in this section was created following a methodology outlined in the article "Consolidating diverse modeling methods and spatial prioritization for multispecies connectivity planning" by Bohnett et al. (2024) published in the journal Frontiers of Conservation Science (https://www.frontiersin.org/journals/conservationscience/articles/10.3389/fcosc.2024.1406944/full). The panther connectivity map was drawn using statewide raster data which was reclassified in ArcGIS Pro. The raster values were sorted into quartiles with the top quartile being reclassified as "high priority" and second quartile as "medium-high priority."

Florida Forever - Recent Acquisitions Map

This map uses a file geodatabase feature class (Florida Forever Acquisitions Plus ARPA August 2024) from Florida Natural Areas Inventory (FNAI.org), https://www.fnai.org/shapefiles/ff_acquired_202408.zip. In ArcGIS Pro, the "Closed Date" attribute of the data used to symbolize the map, based on the year the property was purchased. The data was sorted and symbolized into five classes using a "natural breaks (Jenks)" classification.

Generalized Land Cover Map

This map uses the Cooperative Land Cover (version 3.6) (CLC) data, which was created through a partnership of FNAI and the Florida Fish and Wildlife Conservation Commission (FWC) https://myfwc.com/research/gis/wildlife/cooperative-land-cover/. In ArcGIS Pro the data was reclassified into the land categories in the legend, using the data attribute "Site" according to the following land cover value ranges and descriptions:

Generalized Land Cover Class	CLC Site Number(s)	CLC Site Name(s)
Natural	1110-1730	Upland Hardwood Forest, Mixed Hardwoods, Mesic Hammock, Live Oak, Pine - Mesic Oak, Cabbage Palm, Xeric Hammock, Scrub, Oak Scrub, Sand Pine Scrub, Coastal Scrub, Upland Mixed Woodland, Upland Coniferous, Upland Pine, Sandhill, Mesic Flatwoods, Scrubby Flatwoods, Mixed Hardwood-Coniferous, Successional Hardwood Forest, Shrub and Brushland, Sinkhole, Limestone Outcrop
	2111-2242	Wet Prairie, Mixed Scrub-Shrub Wetland, Marshes, Isolated Freshwater Marsh, Floodplain Marsh, Floating/Emergent Aquatic Vegetation, Cypress/Tupelo (including mixed Cypress/Tupelo), Cypress, Isolated Freshwater Swamp, Floodplain Swamp, Other Coniferous Wetlands, Wet Flatwoods, Pond Pine, Other Hardwood Wetlands, Baygall, Hydric Hammock, Mixed Wetland Hardwoods, Mixed Hardwood-Coniferous Swamps, Cypress/Pine/Cabbage Palm
	7000-7300	Exotic Plants, Brazilian Pepper
	21121-22331	Shrub Bog, Depression Marsh, Basin Marsh, Dome Swamp, Basin Swamp, Hydric Pine Flatwoods, Bay Swamp, Cabbage Palm Hammock, Bottomland Forest
	183111	Oak - Cabbage Palm Forests
	221312-222112	Gum Pond, Cabbage Palm Flatwoods
Developed	1800	Cultural - Terrestrial
	1812-1822	Highway Rights of Way, Low Intensity Urban, High Intensity Urban
	1832-1873	Rural Structures, Transportation, Roads, Communication, Utilities, Extractive, Strip Mines, Sand and Gravel Pits, Rock Quarries
	18211-18212	Urban Open Land, Residential Low Density
	18221-18225	Residential, Med. Density - 2.5 Dwelling Units/AC, Residential, High Density > 5 Dwelling Units/AC, Commercial and Services, Industrial, Institutional
	182111-182135	Urban Open Forested, Urban Open Pine, Parks and Zoos, Golf Courses, Ballfields, Cemetries, Community Rec. Facilities
Working	1810-1811	Mowed Grass, Vegetative Berm
	1831	Rural Open
	1877-1880	Spoil Area, Bare Soil/Clear Cut
	2430-2440	Grazed Wetlands, Clearcut Wetland
	18213	Grass
	18311-18335	Rural Open Forested, Rural Open Pine, Orchards/Groves, Vineyard and Nurseries, Other Agriculture
	183313-183314	Improved Pasture, Unimproved/Woodland Pasture
	183324-183345	Fallow Orchards, Coniferous Plantations, Tree Nurseries, Sod Farms, Ornamentals, Floriculture
	183352	Specialty Farms
	1833151-1833321	Fallow Cropland, Wet Coniferous Plantations
Open Water	3000-4220	Lacustrine, Natural Lakes and Ponds, Clastic Upland Lake, Flatwoods/Prairie/Marsh Lake, River Floodplain Lake/Swamp Lake, Sinkhole Lake, Sandhill Lake, Cultural - Lacustrine, Artificial/Farm Pond, Aquacultural Ponds, Artificial Impoundments/Reservoir, Quarry Pond, Sewage Treatment Pond, Stormwater Treatment Areas, Industrial Cooling Pond, Riverine, Natural Rivers and Streams, Blackwater Stream, Spring-run Stream, Major Springs, Seepage Stream, Cultural - Riverine, Canal, Ditch/Artificial Intermittent Stream
Intensive Ag	183311-183312	Row Crops, Field Crops
	183321-183323	Citrus, Pecan
	183351	Feeding Operations

Table of 20 Most Abundant Land Cover Classes in the Ocklawaha Basin

This table uses the same CLC data as for the generalized land cover map (above). In ArcGIS Pro this statewide data was clipped to the Ocklawaha basin using a shapefile derived from the USGS Watershed Boundary Dataset (https://www.usgs.gov/national-hydrography/watershed-boundarydataset).

The HUC8 subset data was used to extract the Ocklawaha watershed. A number field was appended to the clipped CLC data and the acreage was calculated for the land categories in the Ocklawaha basin. Using summary statistics in ArcGIS Pro, a table was created, and an additional number field added into which the percentage of each land category in the Ocklawaha basin was then calculated.

Unprotected FEGN Priorities Map

This map uses data to identify areas of the state that are protected by conservation programs, to identify areas of the Florida Ecological Greenways Network (FEGN) that are unprotected.

Protected areas were identified using the following GIS datasets:

- Florida Conservation Lands from FNAI.org - https://www.fnai.org/shapefiles/flma_202409.zip
- Florida Forever Board of Trustees Projects from FNAI.org - https://www.fnai.org/shapefiles/ffbot_202409.zip
- Rural and Family Lands Protection Program Projects from FL Dept. of Agriculture and Consumer Services (FDACS) - https://geodata.fdacs.gov/datasets bd047e0835234594baf63300065141ca_0/explore.

The above three GIS layers were combined in ArcGIS Pro using the "union" geoprocessing tool, to create a protected areas layer. This was combined again using the "union" tool, with the FEGN 2021 shapefile from the FL Geographic Data Library - https://fgdl.org/zips/geospatial_data/archive/fegn_2021.zip. The resulting shapefile was then reclassified to identify areas that are either existing conservation areas (i.e., those that are protected), or areas within the FEGN that are unprotected, symbolized according FEGN Priority level.

Table of Summary of CLIP 4.0 Resource Categories by Acres and Percentages of Total Acres

The following CLIP 4.0 resource categories raster datasets were downloaded from FNAI.org - https://www.fnai.org/shapefiles/CLIP_v4_02.zip:

- Biodiversity Resource Priorities
- Landscape Resource Priorities
- Surface Water Resource Priorities
- Groundwater Resource Priorities

In ArcGIS Pro, each of the above four rasters was clipped to the boundary of the Ocklawaha basin using the "extract by mask" geoprocessing tool. Each raster's attribute table was appended with a number field into which acres were calculated for each priority level for that resource.

Using the "Table to Excel" geoprocessing tool, each of the attribute tables was converted and a summary table was created in Microsoft Excel showing the number of acres for each CLIP resource category, by priority level and percentage of the total acres in the Ocklawaha basin.

Spatial Analysis of Critical Land and Waters Identification Project (CLIP) Database

Resource Priority Variables

Input data for this analysis comes from the Florida Natural Areas Inventory (FNAI), University of Florida Center for Landscape Conservation Planning, and the Florida Fish and Wildlife Conservation Commission: https://www.fnai.org/services/clip. Watershed data comes from the USGS Watershed Boundary Dataset: https://www.usgs.gov/national-hydrography/watershedboundary- dataset and hydrographic data comes from USGS National Hydrography Dataset: https://www.usgs.gov/3dhp.

Conducting the analysis using ArcGIS Pro v.3.3.0, watershed data was imported and the Ocklawaha HUC8 watershed and Ocklawaha River were selected, each exported to its own layer, and the watershed projected to an equal area projection (FL Albers…). The Ocklawaha main stem was used to select all the HUC12 watersheds intersecting it within the HUC8 watershed. This area is referred to as "the floodplain." CLIP data was then processed by clipping the raster layers using the HUC8 and the HUC12 watersheds as the clipping geometry (Clip Raster). Next, Zonal Statistics as Table was used to count the number of pixels of each priority value (Zonal Statistics as Table). Finally, Add Field and Calculate Field were executed on the output tables from the previous step and the following expression applied to the pixel counts to calculate acreage (based on the 15 meter2 resolution of the CLIP data): expression = "!COUNT! * 225 / 4046.86"

From there, extraneous fields were deleted and the acreage, count, and description fields were retained for final calculation of percent areas.

REFERENCES

Abbott, Elizabeth F. 1971. *Twenty Springs of the Oklawaha.* An occasional paper with table and photo supplement produced for Florida Defenders of the Environment. https://drive.google.com/file/d/18pOTuxVikqlHGqNyh1RdLannJgndE8SX/view?usp=sharing.

Barcelo & Company. 2022. *Ocklawaha Restoration Benchmark Poll Final Results*. https://npr.brightspotcdn.com/a2/9e/a46957b44b508e0f4674db2fcac3/ocklawaha-restoration-benchmark-poll-final.pdf.

Bellmore, J. Ryan, et al. 2019. "Conceptualizing Ecological Responses to Dam Removal: If You Remove It, What's to Come?" *BioScience* 69:26-39. https://doi.org/10.1093/biosci/biy152.

Best Places.net. n.d. "Climate." Accessed January 6, 2025. https://www.bestplaces.net/climate/city/florida/ocklawaha.

Bi, Xiaohui, Tatiana Borisova, and Alan W. Hodges. 2019. "Economic Value of Visitation to Free-Flowing and Impounded Portions of the Ocklawaha River in Florida: Implications for Management of River Flow." *The Review of Regional Studies* 49(2):244-267. https://rrs.scholasticahq.com/article/9754-economic-value-of-visitation-to-free-flowing-and-impounded-portions-of-the-ocklawaha-river-in-florida-implications-for-management-of-river-flow.

Bohnett, Eve, et al. 2024. "Consolidating Diverse Modeling Methods and Spatial Prioritization for Multispecies Connectivity Planning." *Frontiers of Conservation Science.* https://doi.org/10.3389/fcosc.2024.1406944.

Borisova, Tatiana, Xiaohui Bi, Alan Hodges, and Stephen Holland. 2017. "Economic Importance and Public Preferences for Water Resource Management of the Ocklawaha River." Sponsored project report to the Florida Springs Institute, University of Florida, Food and Resource Economics Department, Gainesville, FL. November 11, 2017, 42 pages. https://drive.google.com/file/d/16AgQPmvXPCb_eerxy5Xxb0uTY97bfTz9/view?usp=sharing.

Bricker, Suzanne B., Christopher G. Clement, Douglas E. Pirhalla, S.Paul Orlando, and Daniel .R.G. Farrow. 1999. *National Estuarine Eutrophication Assessment: Effects of Nutrient Enrichment in the Nation's Estuaries.* NOAA, National Ocean Service, Special Projects Office and the National Centers for Coastal Ocean Science. Silver Spring, MD: 71 pp. https://repository.library.noaa.gov/view/noaa/1693.

Cavacini, Sarah. 2023. "Man Threatens to Bomb Rodman Dam, Authorities Say." *Palatka Daily News*. https://www.palatkadailynews.com/local-news/man-threatens-bomb-rodman-dam-authorities-say.

Center for Landscape Conservation Planning (CLCP). 2021. *Florida Ecological Greenways Network Update Project Final Report*. University of Florida, Gainesville, FL. https://docs.google.com/document/d/1do675kBnhShxGgUQV5E4zsWo03iY_-wj/e?usp=sharing&ouid=107392207950050082451&rtpof=true&sd=true.

Davis, John H. 1967. *General Map of Natural Vegetation of Florida.* Agricultural Experiment Station, IFAS, University of Florida, Gainesville. https://ufdc.ufl.edu/UF00000505/00001/images.

Dobberfuhl, Dean, et al. 2012. *St. Johns River Water Supply Impact Study: Chapter 9. Submerged Aquatic Vegetation*. St. Johns River Water Management District. https://static.sjrwmd.com/sjrwmd/secure/technicalreports/TP/SJ2012-1_Chapter09.pdf.

Federal Emergency Management Agency (FEMA). 2004. *Federal Guidelines for Dam Safety: Hazard Potential Classification System for Dams*. https://www.ferc.gov/sites/default/files/2020-04/fema-333.pdf.

FEMA. 2024. *Community Lifelines*. https://www.fema.gov/emergency-managers/practitioners/lifelines.

Federal Register. 1976. "Determination of Critical Habitat for American Crocodile, California Condor, Indiana Bat, and Florida Manatee." *Federal Register* 41, no. 187 (September 24): 41911-41916. https://archives.federalregister.gov/issue_slice/1976/9/24/41911-41916.pdf#page=4.

Federal Register. 2024. "Proposed Rules, Endangered and Threatened Wildlife and Plants; Critical Habitat Designations for Florida Manatee and Antillean Manatee." *Federal Register* 89, no. 185 (September 24). https://www.fws.gov/sites/default/files/federal_register_document/2024-21182.pdf.

Florida Department of Environmental Protection (DEP). 1997. *Ocklawaha River Restoration Partial Restoration Alternative, Marion and Putnam Counties, Florida*. https://drive.google.com/file/d/1hb07T_nRkQmZRxrF6XJXg7s5dZxBXS8-/view?usp=sharing.

DEP. 2014. *Approved Unit Management Plan Amendment to the Silver Springs State Park Management Plan*. https://floridadep.gov/sites/default/files/2014%20Silver%20Springs%20State%20Park%20Approved%20UMP%20-%20USE.pdf.

DEP. 2015. *Basin Management Action Plan.* https://floridadep.gov/sites/default/files/SilverSprings-BMAP.pdf.

DEP. 2018a. *Marjorie Harris Carr Cross Florida Greenway State Recreation and Conservation Area Unit Management Plan.* https://floridadep.gov/sites/default/files/2018%20Cross%20FL%20Greenway_Final%20ARC%20Draft_CFG%20UMP_20190717.pdf.

DEP. 2018b. *Oklawaha River Aquatic Preserve Management Plan*. https://floridadep.gov/sites/default/files/Oklawaha-River-AP-Management-Plan.pdf.

DEP. 2022. Florida Wildlife Corridor. https://floridadep.gov/sites/default/files/Florida_Wildlife_Corridor.pdf.

DEP. 2024a. *Rodman Recreation Area: Rodman Recreation Area*. Florida State Parks, Florida Department of Environmental Protection. https://www.floridastateparks.org/parks-and-trails/rodman-recreation-area.

DEP. 2024b. *Wildlife Corridor Land Acquisition Status*. https://floridadep.gov/sites/default/files/Summary%20Wildlife%20Corridor%20Funds%20Report%20-%20March%202024.pdf.

DEP. 2024c. *2024 Florida Forever Plan*. https://publicfiles.dep.state.fl.us/DSL/OES/Florida_Forever/Florida_Forever_Annual_Reports/2024%20Florida%20Forever%20Full%20Plan.pdf.

Florida Fish and Wildlife Conservation Commission (FWC). 2024a. *Black Bear Research*. https://myfwc.com/research/wildlife/terrestrial-mammals/bear/research/.

FWC. 2024b. *Florida Manatee*. https://myfwc.com/wildlifehabitats/profiles/mammals/aquatic/florida-manatee/.

FWC. 2024c. *Rodman Reservoir.* https://myfwc.com/fishing/freshwater/sites-forecasts/ne/rodman-reservoir/.

FWC. Undated. *Northeast Region Freshwater Fishing Guide.* https://myfwc.com/media/18611/fwnefishingguide.pdf.

Florida Natural Areas Inventory (FNAI). 2010. *Guide to the Natural Communities of Florida: 2010 Edition*. Florida Natural Areas Inventory, Tallahassee, FL. https://www.fnai.org/PDFs/Full_FNAI-Natural-Community-Classification-Guide-2010_20150218.pdf.

Florida Springs Institute (FSI). 2024. *An Ecological Health Assessment of Silver Springs Florida*. Fish & Wildlife Foundation of Florida. https://drive.google.com/file/d/190BjwLWAPznfPHaHhaMqouMigQwY1KqK/view?usp=sharing.

Florida Statute §259.1055. 2021. *Florida Wildlife Corridor Act*. https://www.flsenate.gov/Laws/Statutes/2021/259.1055#:~:text=(g)%20%E2%80%9CWildlife%20corridor%E2%80%9D,and%20allow%20safe%20movement%20and.

Fulton, Rolland S., III. 2020. *Nutrient Loading and Water Quality Trends in the Upper Ocklawaha Basin Lakes Through 2019-20*. St. Johns River Water Management District. https://drive.google.com/file/d/1e6Xim3icM-YRmb_1EUWowUTO-cT31v1-/view?usp=sharing.

Garman, Greg C. 1992. "Fate and Potential Significance of Postspawning Anadromous Fish Carcasses in an Atlantic Coastal River." *Transactions of the American Fisheries Society* 121:390-394. https://doi.org/10.1577/1548-8659(1992)121%3C0390:FAPSOP%3E2.3.CO;2.

Gende, Scott M., Robert T. Edwards, Michael F. Willson, and Mark S. Wipfli. 2002. "Pacific Salmon in Aquatic and Terrestrial Ecosystems." *BioScience* 52(10):917-928. https://doi.org/10.1641/0006-3568(2002)052[0917:PSIAAT]2.0.CO;2.

Germain-Aubrey, Charlotte C., Pamela S. Soltis, Kenneth M. Neubig, Theresa Thurston, Douglas E. Soltis, and Michael A. Gitzendanner. 2014. "Using Comparative Biogeography to Retrace the Origins of an Ecosystem: The Case of Four Plants Endemic to the Central Florida Scrub." *International Journal of Plant Sciences* 175:418-431. https://doi.org/10.1086/675571.

Haro, Alex, et al. 2000. "Population Decline of the American Eel: Implications for Research and Management." *Fisheries* 25:7-16. http://dx.doi.org/10.1577/1548-8446(2000)025%3C0007:PDOTAE%3E2.0.CO;2.

Harper, Roland M. 1911. "The Relation of Climax Vegetation to Islands and Peninsulas." *Bulletin of the Torrey Botanical Club* 38:515-525. https://doi.org/10.2307/2479382.

Helfman, Gene S. 2007. "Dams, Impoundments, and Other Hydrological Alterations." *Fish Conservation: A Guide to Understanding and Restoring Global Aquatic Biodiversity and Fishery Resources*, 130-157. Island Press, Washington, D.C. https://openlibrary.org/works/OL3356093W/Fish_Conservation.

Hendrickson, John, Kijin Park, and Pete Sucsy. 2015. *Rodman Reservoir Management Drawdown Water Quality Impacts Assessment*. Unpublished Draft Report. St. Johns River Water Management District, Palatka, FL. https://drive.google.com/file/d/1kcdoq2BVCjdihwaaGyMq-oP3kwvT0CbF/view?usp=sharing.

Hendrickson, John. 2016. *Effects on Lower St. Johns River Nutrient Supply and TMDL* Target Compliance from the Restoration of a Free-Flowing Ocklawaha River. Technical Publication SJ2016-1. St. Johns River Water Management District, Palatka, FL. https://drive.google.com/file/d/1E0cEXuHWikIkpWwWoFiHtSIPgn42ccnw/view?usp=sharing.

Hernando County. 2021. *Hernando County Preserves Master Land Management Plan Update: Adaptive Management for Chinsegut Hill, Cypress Lakes, Fickett Hammock, Lake Townsen, and Peck Sink Preserves*. https://www.hernandocounty.us/home/showpublisheddocument/7420/637738757158300000.

Hitt, Nathaniel P., Sheila Eyler, and John E.B. Wofford. 2012. "Dam Removal Increases American Eel Abundance in Distant Headwater Streams." *Transactions of the American Fisheries Society* 141:1171-1179. https://doi.org/10.1080/00028487.2012.675918.

Hoctor, Thomas S., et al. 2024 (Forthcoming). *Refining the Florida Ecological Greenways Network for Improved Landscape Planning and Conservation Prioritization*. *Landscape Ecology*. The Hague: SPB Academic Publishing.

Humborg, Christoph, Venugopalan Ittekkot, Adriana Cociasu, and Bodo v. Bodungen. 1997. "Effect of Danube River Dam on Black Sea Biogeochemistry and Ecosystem Structure." *Nature* 386:385-388. https://drive.google.com/file/d/15_UuujNfAdLlAqoZxGtPeyT846EIhQCb/view?usp=sharing.

Humm, Jacob M., J. Walter McCown, Brian K. Scheick, and Joseph D. Clark. 2017. "Spatially Explicit Population Estimates for Black Bears Based on Cluster Sampling." *Journal of Wildlife Management* 81(7):1187-1201. USGS FWC Grant R1122190563. https://drive.google.com/file/d/1O2JITeE57oouYS33XJRbTgoFJ3leCGjd/view?usp=sharing.

Irvine, A. Blair. 1983. "Manatee Metabolism and Its Influence on Distribution in Florida." *Biological Conservation* 25:314-334. http://dx.doi.org/10.1016/0006-3207(83)90068-X.

Ittekkot, Venugopalan, Christoph Humborg, and Petra Schäfer. 2000. "Hydrological Alterations and Marine Biogeochemistry: A Silicate Issue?" *BioScience* 50(9):776-782. https://drive.google.com/file/d/1m41gJmbRvwsfCkYym4pORhHLgS2gXlnq/view?usp=sharing.

Jarvis, Jessie C., and Kenneth A. Moore. 2008. "Influence of Environmental Factors on Vallisneria americana Seed Germination." *Aquatic Botany* 88(4):283-294. https://drive.google.com/file/d/1WjqidQ2mGRoXBEbfXMc_YDWpMbxvnJTA/view?usp=sharing.

Jordan, Frank. 1994a. *Ocklawaha River Migratory Fish Assessment, Volume 14.* Environmental Studies Concerning Four Alternatives for Rodman Reservoir and the Lower Ocklawaha River. St. Johns River Water Management District, Palatka, FL. https://drive.google.com/file/d/1kfpgM2BrAoMz1-gFt4LiossW_UpCFjf8/view?usp=sharing.

Jordan, Frank. 1994b. *Current Status of the Southern Tessellated Darter (Etheostoma olmstedi maculaticeps) and the Bluenose Shiner (Pteronotropis welaka) in the Ocklawaha River System.* Final Report [Project 94W186] to the St. Johns River Water Management District. Palatka, FL. https://drive.google.com/file/d/13pcShL42Uw4xcEdDSnAAT_CW06ndlrl9/view?usp=sharing.

Kearnan, Kayleigh, and John Waldman. 2024. "Causes of Fish Lift Shutdowns on U.S. East Coast Hydroelectric Dams." *Fisheries* 49:403-411. https://drive.google.com/file/d/1GgRbw6Inx27z6H4iUIXePH2aibAB_4vX/view.

Knight, Robert L. 1980. *Energy Basis of Control in Aquatic Ecosystems.* Ph.D. dissertation. University of Florida, Gainesville, FL. https://ufdc.ufl.edu/AA00022031/00001/images.

Knight, Bob, Ken Sulak, and Bob Virnstein. 2021. *Potential Impacts to Fish Populations with Restoration of the Ocklawaha River.* https://drive.google.com/file/d/1elsbpT2pyfh6VmiLXZUBMVKfG6HM4SaW/view?usp=sharing.

Knutson, Melinda G., and Erwin E. Klaas. 1998. "Floodplain Forest Loss and Changes in Forest Community Composition and Structure in the Upper Mississippi River: A Wildlife Habitat at Risk." *Natural Areas Journal* 18(2):138-150. https://pubs.usgs.gov/publication/1002964.

Laist, David W., and John E. Reynolds III. 2005. "Influence of Power Plants and Other Warm-Water Refuges on Florida Manatees." *Marine Mammal Science* 21:739-764. https://drive.google.com/file/d/1DIzI8UMF16TblyOY_kuk5Dzb7pvMPIy8/view?usp=drive_link.

Lamb, Tom, Timothy Justice, Mary Brewer, Paul Moler, Howard Hopkins, and James Bond. 2017. "A Biogeographical Profile of the Sand Cockroach Arenivaga floridensis and Its Bearing on Origin Hypotheses for Florida Scrub Biota." *Ecology and Evolution.* https://doi.org/10.1002/ece3.3885.

MacAvoy, Stephen E., Stephen A. Macko, S.P. McIninch, and Greg C. Garman. 2000. "Marine Nutrient Contributions to Freshwater Apex Predators." *Oecologia* 122:568-573. https://doi.org/10.1007/s004420050980.

McLane, William M. 1955. *The Fishes of the St. Johns River System.* Ph.D. dissertation. University of Florida, Gainesville, FL. https://www.proquest.com/openview/08f0551ab17347545bf7d8096d395692/1.pdf?pq-origsite=gscholar&cbl=18750&diss=y.

Mead & Hunt. 2021. *Kirkpatrick Dam Inspection Summary Notes.* https://drive.google.com/file/d/1N__cH5_3sBNE-hVuV0MIOS_iRaXtFfm2/view?usp=sharing.

Milanich, Jerald T. 1998. *Florida's Indians from Ancient Times to the Present.* University Press of Florida, Gainesville. https://upf.com/book.asp?id=9780813015989.

Munch, Douglas A., et al. 2006. *Fifty-Year Retrospective Study of the Ecology of Silver Springs, Florida.* St. Johns River Water Management District Special Publication SJ2007-SP4, Palatka, FL. https://ntrl.ntis.gov/NTRL/dashboard/searchResults/titleDetail/PB2010107711.xhtml.

Nagid, Eric J., Travis Tuten, and Kevin G. Johnson. 2015. "Effects of Reservoir Drawdowns and the Expansion of Hydrilla Coverage on Year-Class Strength of Largemouth Bass." *North American Journal of Fisheries Management* 35:54-61. https://doi.org/10.1080/02755947.2014.963750.

National Oceanic and Atmospheric Administration (NOAA). 2024. *Marine Mammal Unusual Mortality Events.* https://www.fisheries.noaa.gov/national/marine-mammal-protection/marine-mammal-unusual-mortality-events.

Noll, Steven. 2004. "Steamboats, Cypress, & Tourism: An Ecological History of the Ocklawaha Valley in the Late Nineteenth Century." *Florida Historical Quarterly* 83(1):6-23. https://stars.library.ucf.edu/cgi/viewcontent.cgi?article=4382&context=fhq.

Noll, Steven, and David Tegeder. 2009. *Ditch of Dreams: The Cross Florida Barge Canal and the Struggle for Florida's Future.* https://upf.com/book.asp?id=9780813061733.

North Florida Land Trust. 2024. *Ocala to Osceola Wildlife Corridor.* https://www.nflt.org/ocala-to-osceola-wildlife-corridor/.

Noss, Reed F. 2013. *Forgotten Grasslands of the South: Natural History and Conservation.* Island Press, Washington, D.C. https://link.springer.com/book/10.5822/978-1-61091-225-9.

Noss, Reed F., William J. Platt, Bruce A. Sorrie, Alan S. Weakly, D. Bruce Means, Jennifer Costanza, and Robert Peet. 2015. "How Global Biodiversity Hotspots May Go Unrecognized: Lessons from the North American Coastal Plain." *Diversity and Distributions.* https://doi.org/10.1111/ddi.12278.

Noss, Reed F. 2018. *Fire Ecology of Florida and the Southeastern Coastal Plain.* University Press of Florida, Gainesville. https://doi.org/10.1002/jwmg.21757.

Odum, Howard T. 1957. "Trophic Structure and Productivity of Silver Springs, Florida." *Ecological Monographs* 27:55-112. https://doi.org/10.2307/1948571.

Oetting, John, Thomas S. Hoctor, and Michael I. Volk. 2016. *Critical Lands and Waters Identification Project (CLIP): Version 4.0*. UF Center for Landscape Conservation Planning, Florida Fish and Wildlife Conservation Commission, and Florida Natural Areas Inventory, Tallahassee, FL. https://www.fnai.org/PDFs/CLIP_v4_technical_report.pdf.

Peel, Murray C., Brian L. Finlayson, and Thomas A. McMahon. 2007. "Updated World Map of the Köppen-Geiger Climate Classification." *Hydrology and Earth Systems Science* 11:1633-1644. http://dx.doi.org/10.5194/hess-11-1633-2007.

Pinto, Gerard, et al. 2024. *2024 State of the River Report for the Lower St. Johns River Basin, Florida: Water Quality, Fisheries, Aquatic Life, & Contaminants*. Prepared for the City of Jacksonville, Environmental Protection Board. https://sjrreport.com.

Poff, N. Leroy, and David D. Hart. 2002. "How Dams Vary and Why It Matters for the Emerging Science of Dam Removal." *BioScience* 52:659-668. https://drive.google.com/file/d/1dzGCNIXhjDm2_YAtGhYT_R9wPzJCgvEs/view?usp=sharing.

Ponnampalam, Louisa S., et al. 2022. "Historical and Current Interactions with Humans." In *Ethology and Behavioral Ecology of Sirenia,* edited by Helene Marsh, 299-349. Switzerland, AG: Springer, Cham. https://drive.google.com/file/d/1g-bo2WLxyD4VHyZYwtaVkNDkpXnGhndR/view?usp=sharing.

Pool, Taylor. 2017. "Future of the Nation's Fisheries and Aquatic Resources: Challenges We Face in 2017 and Beyond." *Fisheries* 42:4. https://doi.org/10.1080/03632415.2017.1259942.

RES. 2024. *Phase 1 Review Suggested 2024 Updates to the Original Cost Estimate for the Ocklawaha River Restoration Project*. Appendix A.

Rosenau, Jack C., Glen L. Faulkner, Charles W. Hendry, and Robert W. Hull. 1977. *Springs of Florida (Rev. ed.)*. Bureau of Geology, Division of Resource Management, Florida Dept. of Natural Resources. https://ufdc.ufl.edu/UF00000232/00002/images.

Ross, Monica, Nicole Bartlett, and Amanda Mathieu. 2023. *Monitoring Manatees and Recreation Use of the Silver River PFS 22-15 Final Report to Protect Florida Springs Tag Grant Program*. https://downloads.regulations.gov/FWS-R4-ES-2024-0073-0003/attachment_19.pdf.

Sanger, Marjory B. 1983. *Forest in the Sand (1st ed.)*. Atheneum, New York. https://archive.org/details/forestinsand0000sang.

Shuman, John R. 1995. "Environmental Considerations for Assessing Dam Removal Alternatives for River Restoration." *Regulated Rivers: Research & Management* 11:249-261. https://doi.org/10.1002/rrr.3450110302.

Silva, Ana T., et al. 2018. "The Future of Fish Passage Science, Engineering, and Practice." *Fish and Fisheries* 19:340-362. https://doi.org/10.1111/faf.12258.

St. Johns River Water Management District (SJRWMD). 2017. *Data Summary: Rodman Reservoir Drawdown*. St. Johns River Water Management District Technical Fact Sheet SJ2017-FS2. https://static.sjrwmd.com/sjrwmd/secure/technicalreports/FS/SJ2017-FS2.pdf.

SJRWMD. 2021. *Rodman Form Submission*. https://www.sjrwmd.com/static/government/Rodman-form-submission.pdf.

SJRWMD. 2023. *Status and Trends Report*. https://www.sjrwmd.com/data/water-quality/#status-trends.

SJRWMD. 2024. *Flood Protection*. Accessed November 26, 2024. https://www.sjrwmd.com/localgovernments/flood-protection/.

South Carolina Department of Natural Resources. 2015. *State Wildlife Action Plan - American Eel*. https://www.dnr.sc.gov/swap/supplemental/diadromousfish/americaneel2015.pdf.

Spontak, Michael. 2020. *Economic Valuation of Properties at Risk of Kirkpatrick Dam Failure*. Located in Appendix D.

Sucsy, Pete, et al. 2011. *Chapter 5: River Hydrodynamics Calibration*. https://static.sjrwmd.com/sjrwmd/secure/technicalreports/TP/SJ2012-1_Chapter05.pdf.

Sutherland, Andrew B., Robert Freese, Jodi B. Slater, Fatih Gordu, Jian Di, and Greenville B. Hall. 2017. *Minimum Flows Determination for Silver Springs, Marion County, Florida*. St. Johns River Water Management District. https://static.sjrwmd.com/sjrwmd/secure/technicalreports/TP/SJ2017-2.pdf.

Stys, Beth, et al. 2017. "Climate Change Impacts on Florida's Biodiversity and Ecology." In *Florida's Climate: Changes, Variations, & Impacts*. http://dx.doi.org/10.17125/fci2017.ch12.

The Biota of North America Program (BONAP). 1971–2000. *PRISM Climate Data*. http://bonap.org/Climate%20Maps/climate48shadeA.png.

Thomson, Cynthia J. 1991. *Effects of the Avidity Bias on Survey Estimates of Fishing Effort and Economic Value*. National Marine Fisheries Service. https://swfsc-publications.fisheries.noaa.gov/publications/CR/1991/9174.PDF.

Tillmanns, Angeline R., Alan E. Wilson, Frances R. Pick, and Orlando Sarnelle. 2008. "Meta-Analysis of Cyanobacterial Effects on Zooplankton Population Growth Rate: Species-Specific Responses." *Archiv für Hydrobiologie* 171(4):285-295. http://dx.doi.org/10.1127/1863-9135/2008/0171-0285.

Tibbals, Charles H. 1990. *Hydrology of the Floridan [sic] Aquifer System in East-Central Florida*. U.S. Geological Survey, Department of the Interior. https://pubs.usgs.gov/pp/1403e/report.pdf.

United States Army Corps of Engineers (USACOE). 2023. *National Inventory of Dams*. https://nid.sec.usace.army.mil/#/dams/system/FL00156/inspections.

United States Fish and Wildlife Service (USFWS). 2008. *Florida Panther Recovery Plan (Puma concolor coryi), Third Revision*. U.S. Fish and Wildlife Service, Atlanta, GA. https://www.fws.gov/sites/default/files/documents/2015-10-01_FL_Panther_RIT_Recovery%20Criteria_Handout_Recovery%20Criteria%20Excerpt%20from%202008%20Florida%20Panther%20Recovery%20Plan.pdf.

USFWS. 2018. *Blue Tilapia (Oreochromis aureus) Ecological Risk Screening Summary*. https://www.fws.gov/sites/default/files/documents/Ecological-Risk-Screening-Summary-Blue-Tilapia.pdf.

United States Forest Service (USFS). 2001. *Final Environmental Impact Statement for the Occupancy and Use of National Forest Lands and Ocklawaha River Restoration*. https://www.fs.usda.gov/Internet/FSE_DOCUMENTS/fseprd585443.pdf.

URS Corporation. 2007. *Emergency Action Plan – Kirkpatrick Dam and Rodman Reservoir (National Inventory of Dams No. 100137)*. https://drive.google.com/file/d/1GAWXaDS7-V_hKUdfQY1AjxW5mwf3bNn4/view?usp=sharing.

Valade, J., R. Mezich, K. Smith, M. Merrill, and T. Calleson, eds. 2020 update. *Florida Manatee Warm-Water Action Plan*. U.S. Fish & Wildlife Service and Florida Fish and Wildlife Conservation Commission. https://myfwc.com/media/28270/wwmap.pdf.

Van Hoose, Natalie. 2024. "Grass-Roots Effort: A Team of Unlikely Allies Is Jump-Starting Eelgrass Recovery on the St. Johns River." *Florida Sportsman*. https://drive.google.com/file/d/1ddBoA-eWDPJPqXHh5YSoc8eUI2QH5ozO/view?usp=sharing.

Volk, Michael I., Thomas S. Hoctor, Belinda B. Nettles, Richard Hilsenbeck, Francis E. Putz, and Jon Oetting. 2017. "Florida Land Use and Land Cover Change in the Past 100 Years." In *Florida's Climate: Changes, Variations, and Impacts,* edited by Eric P. Chassignet, James W. Jones, Vasubandhu Misra, and Jayantha Obeysekera. Gainesville, FL: Florida Climate Institute. http://dx.doi.org/10.17125/fci2017.ch02.

Williams, Christopher P., Thomas M. Scott, and Sam B. Upchurch. 2022. *Florida Geomorphology Atlas*. Special Publication No. 59. Florida Geological Survey, Tallahassee, FL. https://experience.arcgis.com/experience/3fc273fccab8499083960daf7f1207a7.

A father and son fish the St. Johns River. Credit: Stephen Vincent