FISH AND WILDLIFE HABITAT MANAGEMENT GUIDELINES FOR THE AQUATIC RESOURCES OF THE ORANGE CREEK BASIN

Revised March 2024

ORANGE CREEK BASIN WORKING GROUP

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EXECUTIVE SUMMARY

The Orange Creek Basin Working Group (OCBWG), formed in 2005, is comprised of Florida Fish and Wildlife Conservation Commission (FWC) biologists who are either experts or possess applied knowledge in the management of the aquatic habitats for fish and wildlife species present in the Orange Creek Basin (OCB). The OCBWG mission is to implement and coordinate management strategies that promote an equitable habitat distribution approach to optimize the health and diversity of fish and wildlife populations and benefits for people. To achieve this mission, a goal of the OCBWG is to produce science-based guidelines of fish and wildlife habitat requirements for use in the development of specific management actions to monitor, maintain, or alter habitat type, quality and function in response to the dynamic environmental conditions in the OCB. It is the intent of the OCBWG that this guidelines document will communicate how FWC will manage aquatic habitats for fish and wildlife within the OCB, and to inform stakeholders and agencies having management responsibility and/or authority in the OCB. This will be a living document that will be updated as new information becomes available and habitat conditions in a given water body change in response to natural processes or to management activities. This version was updated in March 2024.

This guidelines document was developed to:

- Identify relevant species groups or "focal taxa" (i.e., fish, wading birds, etc.)
- Define available habitat types (i.e., shallow marsh, tree island, etc.)
- Establish suitability of habitat types for each focal taxon
- Evaluate the amount of suitable habitat currently available for each focal taxon using established mapping techniques and Geographic Information System (GIS)
- Provide this information in a format that is easily useable as a dynamic reference
- Apply this process to the three major lakes in the OCB (Lakes Orange, Lochloosa, and Newnans)
- Update this information in a timely manner

This guidelines document can be used to:

- Quantify acreage of available habitats in near real-time
- Identify specific areas to be maintained for current conditions

- Identify specific areas to be managed/altered for preferred conditions
- Predict the impact of a proposed management/alteration action on individual focal taxa
- Develop management actions based on maximum benefit to all focal taxa

Current status

Habitat assessment methods have been established and evaluated and will be applied as determined by environmental and fiscal conditions. These methods have been applied to Lakes Orange, Lochloosa, and Newnans in 2007, 2010, 2013, 2016, 2019, and 2022.

Habitat type and focal taxa

The OCBWG chose eight major habitat types for evaluation of fish and wildlife habitat needs: tree island, shrub swamp, shallow marsh, floating marsh, deep marsh, floating island, open water, and hydrilla (*Hydrilla verticillata*). Furthermore, submersed aquatic vegetation (SAV) occurs within all the described habitat categories and serves an important function to fish and wildlife, as such it was addressed in the context of the habitat categories where it occurs. Fish and wildlife focal taxa were selected because they represented species that exhibited one or more of the following unranked criteria: high economic importance, high recreational importance, sensitive to habitat manipulations, keystone species (a species that has a disproportionate effect on its environment relative to its abundance), and rare or listed (in need of specific habitat protection). Based on these criteria, the following focal taxa were selected for the OCBWG document:

- ***Wading birds*** – highly visible, some listed species, dependent on aquatic habitats, sensitive to changes in habitat quality.
- ***Wood duck*** (*Aix sponsa*) – economically and recreationally valuable species, representative of dabbling ducks.
- ***Ring-necked duck*** (*Aythya collaris*) – economically and recreationally valuable species, representative of diving ducks.
- ***Bald eagles*** (*Haliaeetus Leucoephalus*) – species of conservation emphasis, largely dependent on aquatic habitats for foraging.
- ***Largemouth bass*** (*Micropterus salmoides*) **–** economically and recreationally valuable species, typically occupying vegetated areas of lakes.

- ***Black crappie*** (*Pomoxis nigromaculatus*) **–** economically and recreationally valuable species, typically occupying open-water areas of lakes.
- ***Herpetofauna*** (other than alligators) – turtles, snakes, frogs, and salamanders are important groups of species for food web, and pig frogs (*Lithobates grylio*) are recreationally and economically important. This group represents a major component of biodiversity of lakes.
- ***Alligators*** (*Alligator mississippiensis*) – keystone predator, economically and recreationally valuable species, ecosystem engineer.
- ***Round-tailed muskrats*** (*Neofiber alleni*) – species of conservation emphasis, sensitive to extreme water level fluctuations and habitat changes.

Guidelines required that the habitat objectives for all focal taxa be specific, measurable, achievable, results-oriented, and time-fixed. These habitat objectives were representative of the habitat suitability of specific focal taxa within the system, rather than maximum preferences. For example, it would be unreasonable to suggest that 100% of the system be composed of shallow marsh habitat for the benefit of one focal taxon and to the detriment of other focal taxa.

Habitat matrix evaluation

Each sponsor assessed their focal taxon based on measurable habitat characteristics (metrics) of vegetation, which included: percent of the total lake area for each habitat type; percent area coverage for SAV, emergent, and total vegetation; plant density; vegetative species composition; bottom substrate; location; interspersion; and minimum block size. Focal taxa experts then provided recommendations for each metric that defined a range of desirable conditions for their respective focal taxa. The desired values and/or ranges for each focal taxon were compiled and summarized by habitat type into a tabular format, or habitat matrix. The values in the matrix were then compared to determine where suitable habitat ranges among focal taxa overlap or conflict. An integrated range for each habitat metric was derived by calculating the midpoint of each focal taxon's desirable habitat range, and then selecting the highest and lowest of these midpoints to represent the upper and lower bounds of the integrated range. This process was repeated for all habitat types on each lake to derive an "optimum habitat condition" that would maximize habitat suitability for the broadest range of focal taxa possible. These "optimum"

ranges were used to establish targets for each lake and to evaluate the current conditions of each system in relation to habitat preferences of focal taxa. Adhering to these ranges will ensure the minimum habitat requirements of all focal taxa are met and that no focal taxa are negatively impacted by management activities. Values outside of the integrated ranges should be considered sub-optimal but not necessarily undesirable.

GIS habitat analysis

Color-infrared digital aerial imagery at a pixel resolution of 1 ft (0.3 m) was acquired for the OCB in April to June of 2007, 2010, 2013, and 2022; September 2016, and July 2019. Vegetation communities were mapped within the littoral zones of Lakes Newnans, Lochloosa, and Orange. Photointerpretation with ground truthing was used to identify and delineate areas (polygons) on the imagery that displayed distinct plant-community signatures. GIS analysis was used to identify areas in the lake that contained aquatic plant communities and coverages known to provide usable habitat conditions, including high-quality habitat (provides excellent conditions) and acceptable habitat (provides suitable conditions), for each of the focal taxa. Combined analysis then compared the individual results to generate an overall habitat value for each area of the lake. Areas with the least habitat value were selected as potential management areas, where habitat enhancement activities have the greatest potential to improve habitat conditions with minimal risk of degrading habitat for any of the focal taxa. Future mapping efforts are scheduled to occur on a three-year interval, pending suitable water levels and sufficient funding, so that habitat changes and trends may be documented and incorporated into management planning.

Results

Total mapped coverage of each habitat type was compared to the target ranges from the habitat matrix to evaluate the status of lake wide habitat in each lake during each mapping year. When observed coverage fell short of a target range for a habitat type, it was considered deficient (i.e., insufficient area of that habitat type was available to support the focal taxa). When observed coverage exceeded a target range for a habitat type, it was considered excessive (i.e., the area of that habitat type was more than sufficient to support the focal taxa, and any surplus area of that habitat type could be evaluated as a potential management area for the purpose of increasing the area of deficient habitat types.).

Orange Lake: In 2022, mapped coverage was within 1% of the target ranges for 6 of the 8 habitat types (tree island, floating marsh, deep marsh, floating island, open water, and SAV); above the target range for shrub swamp; and below the target range for shallow marsh. All mapping years showed an excess of shrub swamp habitat and a shortage of shallow marsh habitat, however shrub swamp continued to decrease to its lowest coverage on record in 2022. These data indicate that woody encroachment into herbaceous fringing wetland communities is no longer being regulated by fluctuating water levels or other natural disturbances, which traditionally impact successional patterns in wetland/aquatic systems. While the coverages of most other habitat types appear to vary naturally over time, based on water levels or other environmental factors, shrub swamp and shallow marsh habitats on Orange Lake will require active management to stimulate variability in coverage in order to attain the lake wide habitat targets. Total habitat (high quality + acceptable) in 2022 was greatest of all mapping years for alligator foraging, wading bird foraging, wood duck, and black crappie; total habitat was least of all mapping years for wading bird roosting. Areas that provided the least habitat value for all taxa combined, and coincided with a habitat type that exceeded its target range, were identified as potential management areas. These are locations where projects designed to change the habitat type have the greatest potential to improve habitat conditions for the greatest number of focal taxa and the lowest risk of negatively impacting habitat quality for other focal taxa. The 2022 GIS analysis identified 850 acres of potential management area, all of which was categorized as shrub swamp habitat.

Lochloosa Lake: In 2022, mapped coverage was within 1% of the target ranges for all habitat types except shallow marsh, which was 5% below target. Because observed coverages were very near target ranges, no conversion of habitat is recommended, and no potential management areas have been identified at this time. Total habitat in 2022 was greatest of all mapping years for alligator foraging, wading bird foraging, ring-necked duck, wood duck, black crappie, and largemouth bass. The 2019 and 2022 mapping events occurred during an extended period of significantly higher water levels, more than two feet higher on average, than water levels observed in 2007, 2010, and 2013. Standing water was present in the right-arm marsh, particularly in boat trails, which contributed to higher habitat values (compared to 2007, 2010, and 2013) for multiple taxa. The data illustrate the significant role that water level plays in the overall habitat value of the right-arm marsh. When compared to years when the marsh lacks a

significant hydrologic connection to the main lake basin, overall habitat value for all taxa combined nearly doubles when water levels are high enough to reconnect the vast network of pools and boat trails to the main pool of the lake.

Newnans Lake: Most habitat types on Newnans Lake were outside the target ranges in 2022 with shrub swamp, shallow marsh, floating marsh, and deep marsh falling short of their respective target ranges, and open water exceeding its target range. In all years, mapped coverage fell short of the target range for shallow marsh and was below the midpoint of the target ranges for all other habitat types except open water. In 2022, total habitat was least of all years for alligator nesting, herpetofauna, round-tailed muskrat, wading bird foraging and roosting, and largemouth bass; total habitat was greatest of all mapping years for alligator foraging and black crappie. The overwhelming majority of area within the lake that ranked "low" for overall habitat value for all taxa combined occurred within the open water habitat type. Newnans Lake has historically had a sparsely vegetated littoral zone, with the only exceptions being recent periods of drought recovery in which habitat quality dramatically improved due to increased vegetation that germinated during low water conditions around the perimeter of the lake. However, water level fluctuations tend to be flashy with rapid increases in water depth occurring frequently. Sustained average water levels within the littoral zone are often too deep for rooted emergent vegetation to expand naturally, and most of the lake is surrounded by cypress and bottomland hardwood forest. Efforts to improve lake-wide habitat conditions on Newnans Lake must focus on expanding littoral vegetation and SAV. Therefore, all open water areas of the lake where average water depths are less than four feet should be considered potential management areas.

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INTRODUCTION

The Florida Fish and Wildlife Conservation Commission (FWC) has traditionally developed and implemented lake management plans that focused on improving habitat conditions for a single fish or wildlife species, such as largemouth bass (*Micropterus salmoides*). In the early 2000's, agency reorganization and associated rewriting of the FWC Strategic Plan incorporated the concept of a team approach for effective management of fish and wildlife resources. Under this approach, when teams or working groups are formed, they are expected to involve experts from multiple disciplines to provide a broader perspective for the issues being addressed. The intent is to ensure that the issues being addressed are evaluated more thoroughly and better solutions are produced.

The FWC Orange Creek Basin Working Group (OCBWG), formed in 2005, is composed of resource biologists who have specific knowledge of and expertise in fish and wildlife species and their habitats in the Orange Creek Basin (OCB). The mission and goal of the OCBWG, stated in more detail below, is to produce a holistic guiding document for the development of lake-specific habitat management plans. This document is a set of management guidelines to be followed when subsequently developing a management plan. This approach was preferred by the OCBWG because management plans need to account for the dynamic changes that occurs in the fish and wildlife populations and the habitats present in the water bodies of the OCB, particularly in Orange Lake. As such, previous management plans for the OCB were either not fully implemented or quickly became obsolete as a result of the changing conditions that occur within the OCB.

The approach of first developing broad-based resource management guidelines has become an important element for developing aquatic habitat management plans. These guidelines provide a science-based framework for understanding potential tradeoffs in benefits and costs to fish and wildlife populations that can result from specific management actions. This approach is consistent with the mission of the FWC: To manage fish and wildlife resources for their long-term well-being and the benefit of people.

These guidelines incorporate a comprehensive set of habitat descriptions, along with summaries of habitat conditions required to maintain or enhance robust populations of the fish and wildlife that are present. Further, this document incorporates a scientific modeling approach for analyzing the dynamic relationships between habitat preferences of the multiple species that are present and the availability of their preferred habitats. This document will serve as a guide for the development of cooperative habitat management plans for the major water bodies within the OCB. Therefore, the focus of these guidelines is on lakes and not other waters (i.e., streams, wetlands). This document is not intended to stand alone as a management plan for the OCB. Instead, this document is intended to serve as a primary reference to the resource managers who will develop future management plans. This approach will result in sound, effective, science-based management strategies that are formulated as management needs arise. This will be a living document that will be updated as new information becomes available and habitat conditions in a given water body change in response to natural processes or to management activities.

OCBWG MISSION

Implement and coordinate management strategies within the OCB that promote an equitable habitat distribution approach to optimize the health and diversity of fish and wildlife populations and benefits for people.

OCBWG VISION

Create and maintain a diverse and healthy ecosystem within the OCB that balances the needs of healthy fish and wildlife populations with sustainable public use.

OCBWG GOAL

Facilitate the long-term maintenance and enhancement of aquatic fish and wildlife habitats in the OCB.

OCBWG OBJECTIVES

1. Identify and define the habitat types represented within the OCB.
2. Identify important fish and wildlife focal taxa and the quality and quantity of habitats in which they exist.
3. Provide a framework for developing management priorities, work plans and research needs in order to ensure that agency resources are directed efficiently and effectively.
4. Define and communicate the FWC's position on how to manage the diverse aquatic habitats for fish and wildlife within the OCB.

BACKGROUND AND METHODS

OCB PHYSICAL ENVIRONMENT AND MANAGEMENT HISTORY

The OCB is a sub-drainage of the lower Ocklawaha River Basin and drains approximately 1,000 mi^2 (1,550 km^2) in Alachua, Marion, and Putnam counties (Lasi and Shuman 1996). The OCB is comprised of six sub-basins: Hogtown Creek, Paynes Prairie, Newnans Lake, Lochloosa Lake, Orange Lake, and Orange Creek. Surface drainage within the OCB flows from Hogtown Creek to Paynes Prairie, Newnans Lake to Paynes Prairie, Paynes Prairie to Orange Lake, Lochloosa Lake to Orange Lake, and Orange Lake to Orange Creek (Figure 1; Lasi and Shuman 1996).

The three major lakes in the OCB (Lakes Newnans, Lochloosa, and Orange) can be characterized as large (6,700, 8,400, and 12,700 acres, respectively), shallow (5, 7, and 5.6 ft average depth, respectively), and eutrophic systems, due in part to the geomorphology of the lakes (Gottgens and Montague 1987, Lasi and Shuman 1996). These lake basins are dominated by the Hawthorne Formation, which consists of phosphatic sands, clays, and limestone, and acts as a confining layer to the Floridian Aquifer (Brooks 1982). In addition, Orange Lake contains a portion of the Ocala Group at the surface that is characterized by karst topography with sinkhole and solution features.

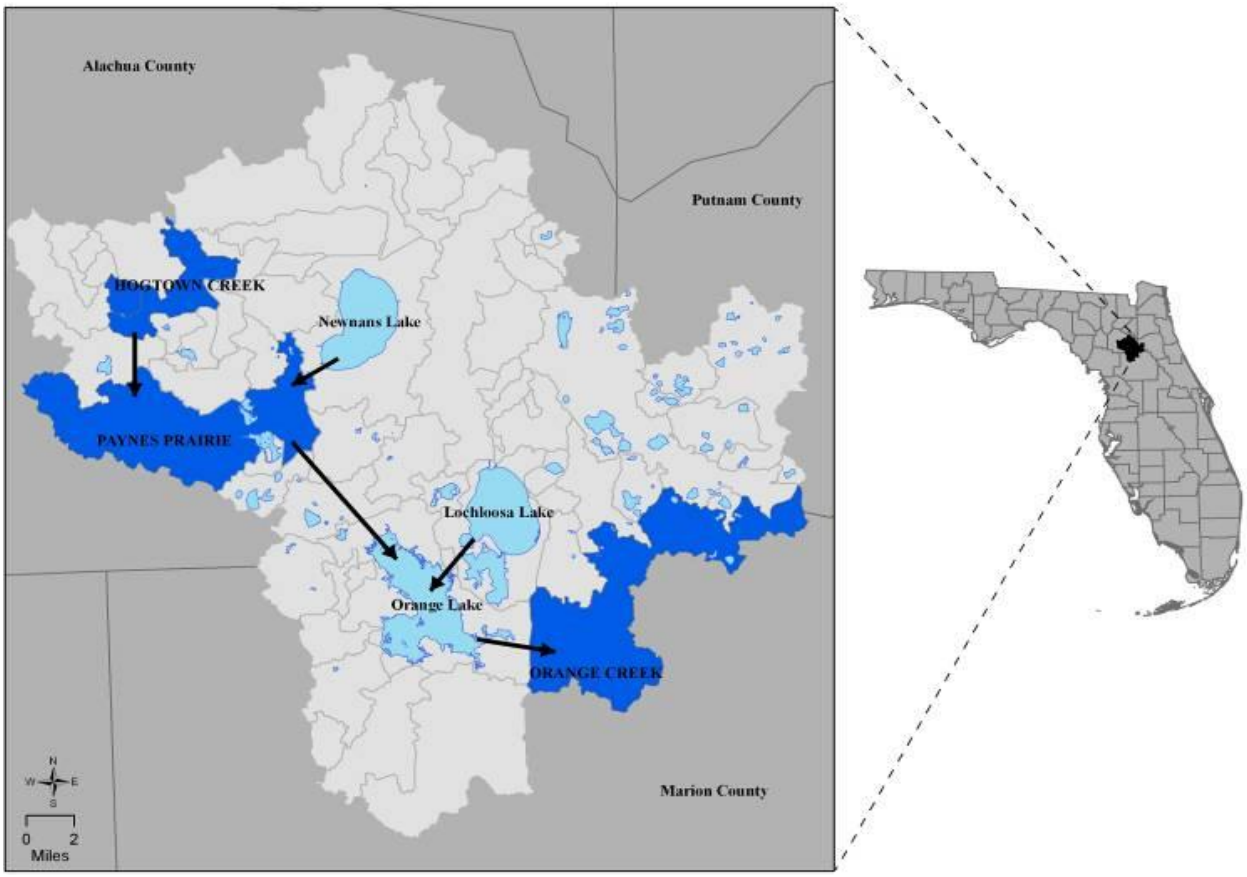

Figure 1. Map of the Orange Creek Basin located within Alachua, Putnam, and Marion Counties. Primary sub-basins and lakes are labeled. Arrows indicate flow direction of surface drainage.

Due to high productivity, Lakes Newnans, Lochloosa, and Orange have historically supported abundant and diverse fish and wildlife. In particular, the fisheries resources within the three lakes significantly contribute to the local economy, and these lakes were designated as Fish Management Areas in 1963 in a cooperative agreement between the Florida Game and Freshwater Fish Commission and Alachua County. Studies conducted on Orange Lake in 1977 and 1986 estimated the annual economic value of the largemouth bass fishery as 1 million dollars (Colle et al. 1987) and 5 million dollars (Milon et al. 1986), respectively. Consequently, Lakes Newnans, Lochloosa, and Orange have been primarily managed for their fisheries. In addition, due to their exceptional recreational and ecological significance, Lochloosa Lake, Orange Lake, Cross Creek, and River Styx were designated as "Special Water" Outstanding Florida Water by the Florida Department of Environmental Protection Agency in 1987.

Since the mid-1970s, these lakes have experienced drastic changes in aquatic macrophyte abundance and species composition, eutrophication, and more recently, record high and low water levels. These processes have presented challenges to multiple agencies involved in aquatic resource management of the OCB. The FWC manages fish and wildlife through harvest restrictions, stock enhancements, and habitat manipulation. Additionally, FWC's Invasive Plant Management Section, formerly housed in the Florida Department of Environmental Protection (FDEP), spends considerable effort and resources managing exotic and invasive aquatic plants. The FDEP sets Total Maximum Daily Loads (TMDL) in waterbodies, including the OCB, to quantify pollutant reductions that are needed to achieve water quality targets based on state water quality standards. The FDEP recently produced an Orange Creek Basin Management Action Plan with strategies aimed at achieving target levels. The St. Johns River Water Management District assists in the TMDL process by developing Pollutant Reduction Management Goals, and is also responsible for setting minimum flows and levels in all water bodies in the OCB. Alachua County acquires, manages, and improves environmentally significant lands in the OCB to protect habitat and water resources, and ensures that new and existing developments comply with Alachua County's land development regulations. However, effective long term management of lakes within the OCB for fish and wildlife values has been elusive primarily due to human population growth, habitat alteration and degradation, and lack of a unified and comprehensive management plan supported by all agency and public stakeholder groups. A recent paper recommended that integrated management plans should be produced for all public water bodies in Florida (Hoyer et al. 2005).

Natural processes that historically occurred during extreme flood and drought events have been severely altered as a result of changes within the OCB. Sediment and vegetative transport during floods have been hindered by modifications to the Orange Lake outlet (U.S. 301 weir). Burning of excessive plant material during droughts has been eliminated by fire prevention due to safety concerns associated with nearby interstates and highways. Therefore, resource managers have relied on habitat management practices that mimic these processes. During drought conditions, practices such as organic sediment removal have been used to delay or set back succession and provide firm substrate for vegetation root structure. Sediment tilling has been used to aerate the substrate and break up the root structure of tussock-forming vegetation to mitigate excessive floating islands. During average water levels, practices such as mechanical shredding (i.e., cookie-cutter) have been used to maintain navigation channels and break-up floating marshes to maintain connectivity between the deep marsh and shallow marsh habitats. Similarly,

mechanical vegetation harvesting has been used to accomplish this goal, with the added benefit of removing the harvested material from the lake to avoid additional organic deposition. Finally, herbicide applications have been regularly used to maintain control of exotic and invasive aquatic vegetation. Although most of these management strategies have traditionally focused upon fish population goals, the overall objectives were to mitigate aquatic plant succession and maintain the diverse vegetative composition within and among habitat types in the OCB.

HABITAT TYPES AND FOCAL TAXA

The habitat types of Orange Lake were previously described, classified, and/or quantified by Bryan and Warr (1998), Clarke and Reddy (1998), and Warr et al. (1999). In addition to providing a baseline of vegetative composition and locations of major aquatic habitat types in Orange Lake, these reports provide a definition of habitats that are represented to varying degrees in wetlands and lakes throughout the OCB. Therefore, these definitions were referenced and incorporated into this document for standardization purposes. The six major habitat types were tree island, shrub swamp, shallow marsh, floating marsh, deep marsh, and floating island. Sub-categories of most types were also defined by Bryan and Warr (1998), and often were included with the classification used in this document.

In addition to the previously classified habitat categories, the OCBWG included habitat categories for open water and hydrilla (*Hydrilla verticillata*) to account for all remaining areas within the lake boundaries. Hydrilla can have profound ecological costs and benefits to some species of fish and wildlife. The OCBWG determined that it was necessary to address those issues directly to provide managers with the tools they need to make effective management decisions when controlling hydrilla in the OCB. Furthermore, submersed aquatic vegetation (SAV) occurs within all the described habitat categories and serves an important function to fish and wildlife, as such it was addressed in the context of the habitat categories where it occurs.

Habitat objectives for the OCB were derived by examining important fish and wildlife focal taxa and evaluating their habitat needs (Ryti 1992, Pearman et al. 2006). The habitat requirements for each focal taxon were defined by species experts using available biological literature combined with professional judgment. General assumptions for habitat use by focal taxa were determined and then used as the basis for evaluating habitat suitability within the OCB. Focal taxa that were selected were identified because they represented species that exhibited one or more of the following unranked criteria:

- High economic importance.
- High recreational importance.
- Sensitive to habitat manipulations.
- Keystone species (a species that has a disproportionate effect on its environment relative to its abundance).
- Rare or listed, and in need of specific habitat protection.

Based on these criteria, the following focal taxa were selected for the OCBWG document:

- ***Wading birds*** – highly visible, some listed species, dependent on aquatic habitats, sensitive to changes in habitat quality.
- ***Wood duck*** (*Aix sponsa*) – economically and recreationally valuable species, representative of dabbling ducks.
- ***Ring-necked duck*** (*Aythya collaris*) – economically and recreationally valuable species, representative of diving ducks.
- ***Bald eagles*** (*Haliaeetus leucocephalus*) – species of conservation emphasis, largely dependent on aquatic habitats for foraging.
- ***Largemouth bass*** **–** economically and recreationally valuable species, typically occupying vegetated areas of lakes.
- ***Black crappie*** (*Pomoxis nigromaculatus*) **–** economically and recreationally valuable species, typically occupying the open water areas of lakes.
- ***Herpetofauna*** (other than alligators) – turtles, snakes, frogs, and salamanders are important groups of species for food web, and pig frogs (*Lithobates grylio*) are recreationally and economically important. This group represents a major component of biodiversity of lakes.
- ***Alligators*** (*Alligator mississippiensis*) – keystone predator, economically and recreationally valuable species, ecosystem engineer.
- ***Round-tailed muskrats*** (*Neofiber alleni*) – species of conservation emphasis, sensitive to extreme water level fluctuations and habitat changes.

Each fish and wildlife focal taxon was sponsored by a member of the OCBWG with specific expertise in the habitat requirements of the taxon they were asked to represent. Each sponsor developed a document containing the overall management goal, rationale, and habitat-specific objectives for their focal taxon (Appendix A). Guidelines required that the habitat objectives for all focal taxa be specific, measurable, achievable, results-oriented, and time-fixed. These habitat objectives were representative of the habitat suitability of specific focal taxon within the system, rather than maximum preferences. For example, it would be unreasonable to suggest that 100 % of the system be composed of shallow marsh habitat for the benefit of one focal taxon and to the detriment of other focal taxa.

Invertebrates are an integral component of freshwater food webs and are vital to the decomposition and nutrient cycling processes. Invertebrates provide an essential food resource for alligators, wading birds, waterfowl, centrarchid fish, mammals, and herpetofauna in the OCB. The major habitat types used in this document were evaluated by an invertebrate expert regarding the potential composition of the invertebrate assemblages that may occur in those habitats based on similar habitat assemblage surveys conducted at other Florida lakes (Appendix B). Invertebrate focal taxa were not identified or included in the initial habitat objectives analyses for the water bodies in the OCB but may be included in future revisions.

INVASIVE PLANT MANAGEMENT

Invasive plants degrade and diminish Florida's conservation lands and waterways (http://myfwc.com/wildlifehabitats/invasive-plants/). Some invasive aquatic plants pose a significant threat to human welfare by impeding flood control and affecting recreational use of waterways and its associated surrounding economy. The guideline is to keep water hyacinth (*Eichhornia crassipes*) and water lettuce (*Pistia stratiotes*) populations at extremely low levels

(less than 5 acres [2 ha]), maintaining maintenance level control. This prevents damage to beneficial species, reduces organic deposits on the lake bottom, and reduces herbicide usage. Monocultures of Cuban bulrush (*Cyperus blepharoleptos*) in floating marsh habitats are managed to maintain mobility throughout waterways and to protect native emergent plants from competition and shading. Strategies implemented to achieve management goals can include but are not limited to herbicide, mechanical treatment, or biological control. Hydrilla management is addressed below in the Habitat Classifications section under the heading Hydrilla.

IMPERILED SPECIES

The imperiled species listing status for Florida has been revised based on listing of the U. S. Fish and Wildlife Service (Federal) and listing of the FWC (Florida). The three categories are Federal endangered, Federal threatened, and Florida threatened, and each category is unique with no duplication of species between lists (http://myfwc.com/wildlifehabitats/imperiled/). Species Action Plans for the species on the current Florida threatened and species of special concern lists are being developed with the goal of restoring habitats and species populations so that species can be removed from the lists.

Florida listed species whose ranges include the OCB are:

Aquatic species

- Squirrel chimney cave (or Florida cave) shrimp (*Palaemonetes cummingi)*−Federal threatened,
- Bluenose shiner (*Pteronotropis welaka*)−Florida threatened,
- Southern tessellated darter *(Etheostoma olmstedi maculaticeps*)−Florida threatened.

Terrestrial species

- Red-cockaded woodpecker (*Picoides borealis)*−Federal endangered,
- Wood stork (*Mycteria Americana)*−Federal threatened,
- Eastern indigo snake (*Dymarchon corais couperi)*−Federal threatened,
- Florida scrub-jay (*Aphelocoma coeruluscens)*−Federal threatened,
- Florida burrowing owl (*Athene cunicularia floridana*)−Florida threatened,
- Florida pine snake (*Pituophis melanoleucus mugitus*)−Florida threatened,
- Florida sandhill crane (*Grus canadensis pratensis*)−Florida threatened,
- Gopher tortoise (*Gopherus polyphemus*)−Florida threatened,
- Little blue heron (*Egratta caerulea*)−Florida threatened,
- Short-tailed snake (*Lampropeltis extenuata*)−Florida threatened,
- Southeastern American kestrel (*Falco sparverius paulus*)−Florida threatened,
- Tricolored heron (*Egratta tricolor*)−Florida threatened.

The OCBWG is not directly responsible for the management or restoration of imperiled species. For the imperiled species whose ranges occur within the OCB, the OCBWG will review each finalized management plan to ensure that these guidelines do not conflict with the plan. While the majority of listed species within the OCB are terrestrial, these species will be considered when planning and performing management activities. Any management actions that affect the

660 ft (200 m) disturbance buffer around a bald eagle nest should follow the guidance of the Bald Eagle Management Plan (FWC 2008).

HABITAT CLASSIFICATIONS

TREE ISLAND

Tree islands are typically small areas (<10 acres [<5 ha]) dominated by mature trees (e.g., red maple [*Acer rubrum*] and bald cypress [*Taxodium distichum*]) that are isolated from the shoreline of a lake (Photo 1). They are frequently found in areas where small hammocks rise above the surrounding wetland topography. Tree islands are only periodically inundated, and water depths rarely exceed 3 ft (1 m). Tree islands should not be confused with large floating islands that may be comprised of low growing herbaceous plants and/or small trees and woody vegetation.

Focal taxa utilizing this habitat include:

- Wading birds - Habitat edge utilized for foraging and loafing, islands inundated by or surrounded with water could provide good roosting and nesting habitat.
- Herpetofauna - This habitat is not particularly important for most aquatic herpetofauna species, except as nesting areas for alligators, turtles and snakes. However, tree islands situated along the shoreline could potentially be used by a wide variety of terrestrial or arboreal species (including lizards) that are rare in other (primarily aquatic) habitat types. Maintaining small amounts of this habitat will aid in conserving species diversity.
- Bald eagle - Tree islands with mature trees may be used as nesting sites.

Typical plants that provide habitat value include: bald cypress, buttonbush (*Cephalanthus occidentalis*), cabbage palm (*Sabal palmetto*), red maple, wax myrtle (*Myrica cerifera*), and willow (*Salix* spp.).

Strategies implemented to maintain and promote these habitat characteristics can include but are not limited to burning and herbicide application.

Photo 1. Tree island.

SHRUB SWAMP

Shrub swamps are dominated by small trees and shrubs intermixed with other (understory) wetland vegetation (Photos 2 and 3). They generally occur in areas where surrounding hardwood swamps transition into shallow marsh habitats or near the perimeter of tree islands. The shrub swamp community is a transition of shallow marsh succession towards a hardwood swamp climax community. Sub-categories of this type include A) mixed shrub swamp, dominated by wax myrtle, elderberry (*Sambucus canadensis*), and/or buttonbush, often intermixed with willow, and B) willow shrub swamp, dominated by willow.

Focal taxa utilizing this habitat include:

- Wading birds - Habitat edge utilized for foraging, loafing, nesting, and roosting.
- Waterfowl – Wood ducks utilize this habitat for forage and cover.
- Herpetofauna – This habitat is not particularly important for most herpetofauna species, although it is potentially used by a wide variety of species, including frogs, arboreal snakes, and lizards.
- Round-tailed muskrats - This habitat is important for foraging and loafing when adjacent to maidencane (*Panicum hemitomon*) shallow marsh.

Typical plants that provide habitat value include: arrow arum (*Peltandra virginica*), buttonbush, elderberry, wax myrtle, and willow.

Strategies implemented to maintain and promote these habitat characteristics can include but are not limited to burning, maintaining natural water fluctuations, and herbicide application.

Photo 2. Mixed shrub swamp.

Photo 3. Willow shrub swamp.

SHALLOW MARSH

Shallow marshes are dominated by rooted emergent vegetation, often intermixed with SAV (Photos 4, 5, 6, and 7). Water level is an important component of this habitat type. Low water events can cause the formation of shallow marsh as floating marsh habitat sinks and becomes attached to bottom sediments. Conversely, high water events can uproot shallow marsh and

cause the formation of floating islands and floating marsh. Shallow marshes are highly variable in plant composition, with some areas dominated by one or more characteristic species, and other areas a conglomerate of multiple species. Sub-categories of this type include A) maidencane shallow marsh, dominated by maidencane, B) tall linear-leaved shallow marsh, dominated by cattail (*Typha latifolia*), bulrush (*Schoenoplectus* spp.), and/or sawgrass (*Cladium jamaicense*), C) flag shallow marsh, dominated by pickerelweed (*Pontederia cordata*), arrowheads (*Sagittaria* spp.), and/or arrow arum, and D) mixed shallow marsh, consisting of multiple species.

Focal taxa utilizing this habitat include:

- Wading birds - Habitat edge utilized for foraging, loafing, and nesting.
- Waterfowl - Wood ducks and dabbling ducks utilize for forage and cover.
- Herpetofauna – A variety of frogs, salamanders, turtles, snakes, and alligators, including primarily terrestrial species that forage and/or breed in this habitat. Alligators commonly nest in sawgrass, cattail, and maidencane stands.
- Round-tailed muskrat - This habitat is directly important to muskrats for foraging.

Typical plants that provide habitat value include: frog's-bit (*Limnobium spongia*), maidencane, sawgrass, and a mixture of vegetation consisting of arrowhead, bulrush, maidencane, pickerelweed, and sedges.

Strategies implemented to maintain and promote these habitat characteristics can include but are not limited to shredding, harvesting, burning, rotovating, and herbicide application.

Photo 4. Maidencane shallow marsh.

Photo 5. Tall linear-leaved shallow marsh.

Photo 6. Flag shallow marsh.

Photo 7. Mixed shallow marsh.

FLOATING MARSH

Floating marshes are composed of native or exotic plants growing on a buoyant mat consisting of plant roots and organic matter (Photos 8 and 9). Although floating marshes often contain floating aquatic plant species, they are not made up entirely of floating aquatic vegetation (Mallison et al. 2001). Floating marshes are attached to the shoreline (i.e., not free-floating) and typically occur near the eco-tone of the shallow and deep marshes. The floating marsh community often acts as a pre-cursor for floating island development. Sub-categories of this type include A) low floating marsh, dominated by smaller species such as Cuban bulrush, water pennywort (*Hydrocotyle* spp.), frog's-bit, and/or knotweed (*Polygonum densiflorum*), and B) complex floating marsh, dominated by larger species such as water primrose (*Ludwigia* spp.), pickerelweed, cattail, bur marigold (*Bidens* spp.), and/or multiple other species. The low floating marsh sub-category was a combination of two sub categories described by Bryan and Warr (1998), sedge floating marsh and low floating marsh.

Focal taxa utilizing this habitat include:

- Wading birds - Habitat edge utilized for foraging and loafing.
- Herpetofauna – A variety of semi-aquatic and aquatic herpetofauna.
- Round-tailed muskrat - This habitat is directly important to muskrats with habitat edge utilized for foraging.

Typical plants that provide habitat value include arrow arum, arrowhead, frog's-bit, and knotweed.

Strategies implemented to maintain and promote these habitat characteristics can include but are not limited to maintaining a full range of normal water level fluctuations, spot treatment of woody vegetation, and burning.

Photo 8. Low floating marsh.

Photo 9. Complex floating marsh.

DEEP MARSH

Deep marshes are composed of rooted emergent and/or floating-leaved vegetation, often intermixed with SAV (Photos 10 and 11). Deep marshes are typically located lake-ward of the shallow marsh/floating marsh complex in water depths of 3 to 8 ft (1 to 2.5 m). Deep marsh habitat is dynamic and often compromised with the formation and movement of floating islands and floating marsh habitats. Deep marshes are often displaced by floating islands when high water returns after a drought. Therefore, lake wide coverage of deep marshes often depends on floating island coverage and lake stage, which facilitates the mobility of floating islands. Sub-categories of this type include A) floating-leaved deep marsh, dominated by spatterdock (*Nuphar* spp.), water lilies (*Nymphaea* spp.) and/or American lotus (*Nelumbo* spp.), and B) knot-grass deep marsh, dominated by Egyptian paspalidium (*Paspalidium geminatum*) and/or maidencane.

Focal taxa utilizing this habitat include:

- Largemouth bass and black crappie - Habitat utilized for spawning, cover, and forage. Due to low dissolved oxygen beneath floating mats of vegetation, floating islands and floating marshes should be limited (<10% coverage) within the deep marsh habitat.
- Wading birds - Habitat edge occasionally utilized for foraging and loafing when vegetation is thick enough to support birds' body weight.
- Waterfowl - Ring-necked and other diving ducks utilize this habitat for foraging and cover.
- Herpetofauna - Aquatic salamanders (*Amphiuma* spp., *Siren* spp.), turtles, and alligators regularly use this habitat to forage.
- Round-tailed muskrat - This habitat is directly important to muskrats with habitat edge utilized for foraging.

Typical plants that provide habitat value include: coontail (*Ceratophyllum demersum*), Egyptian paspalidium, American lotus, southern naiad (*Najas guadalupensis*), spatterdock, and water lily.

Strategies implemented to maintain and promote these habitat characteristics can include but are not limited to shredding, harvesting, herbicide application, and planting desirable native rooted emergent vegetation.

Photo 10. Floating-leaved deep marsh.

Photo 11. Grass deep marsh.

FLOATING ISLAND

Floating islands have the same characteristics as floating marshes, but are free-floating (Photo 12). Abundance and distribution may vary dramatically immediately following a drought or flood events. The transient nature of floating islands and their tendency to displace beneficial deep marsh habitat and impede public access has prompted lake managers to place a high priority on identifying management strategies for this habitat type. The two subcategories (dense

and low floating islands) described by Bryan and Warr (1998) are combined in this document because the two types function similarly in terms of fish and wildlife habitat value.

Focal taxa utilizing this habitat include:

- Largemouth bass and black crappie – Habitat edge utilized for foraging and cover.
- Wading birds - Habitat edge utilized for foraging, loafing, and nesting.
- Herpetofauna– Floating islands are potentially used by a wide variety of herpetofauna, although relatively little is known regarding actual usage. Alligators commonly use floating islands for nesting.
- Round-tailed muskrat - This habitat is directly important to muskrats with habitat edge utilized for foraging.

Typical plants that provide habitat value include arrowhead, arrow arum, knotweed, maidencane, and a mixture of vegetation.

Strategies implemented to maintain and promote these habitat characteristics can include but are not limited to maintain a full range of normal water level fluctuations, spot treatment of woody vegetation, and burning.

Photo 12. Floating island.

OPEN WATER

Open-water areas are defined by the absence of emergent vegetation (Photo 13). These areas typically contain less than 5% vegetative coverage, other than SAV, and often occur in the middle, limnetic region of the lake where water depths typically range from 5 to 10 feet (1.5 to 3m). Lake wide coverage of open-water habitat depends on lake stage and length of time since a low-water event has occurred (Warr 1999), and coverage of hydrilla.

Focal taxa utilizing this habitat include:

- Fish – Important for black crappie foraging.
- Wading birds - Habitat utilized for foraging in shallow water depths.
- Waterfowl – Will use open water, particularly where hydrilla is present or near the surface.
- Herpetofauna – Alligators regularly use open water for foraging, courtship, thermoregulation, and refuge from other alligators. Florida softshell turtles (*Apalone ferox*) use open water for foraging. Florida snapping turtles (*Chelydra serpentine osceola*), musk turtles (*Sternotherus odoratus*), and mud turtles (*Kinosternon* spp.); and greater sirens (*Siren lacertian*) and two-toed amphiumas (*Amphiuma means*) may also use the benthic zone of open water for foraging.
- Bald eagle - Will use open water to hunt for fish or waterfowl.

Within the open-water habitat, manage indefinitely the defined open-water areas of the lake to maintain regions that are void of dense vegetation. Evaluate areas of encroaching SAV for benefits to wildlife species, especially waterfowl, and determine the best time of year and methods of removal if the benefits for wildlife and navigation suffer a decline.

Strategies implemented to maintain and promote these habitat characteristics can include but are not limited to shredding, harvesting, burning, rotovating, and herbicide application.

Photo 13. Open water.

SAV / HYDRILLA

Hydrilla (Photo 14) is a persistent invasive aquatic plant that can grow in almost any freshwater region and in water depths that range from a few inches to over 30 ft (9.1 m) in depth. Additionally it can grow in oligotrophic (low nutrient) to eutrophic (high nutrient) conditions as well as in areas of low light where it can out compete native plants. FWC prefers to manage for

native aquatic plants, but recognizes that in water bodies where native submersed aquatic plants are absent or limited, hydrilla at low to moderate densities can be beneficial to fish and wildlife (http://myfwc.com/media/1386750/hydrilla-mgmt-position.pdf). On Orange Lake, hydrilla is the dominant submersed aquatic plant and the OCBWG decided that it should be treated as a separate habitat type. On other systems, or if conditions change on Orange Lake, this habitat type may be alternatively named "Submersed Aquatic Vegetation."

Hydrilla is a primary influence upon habitat quality for fisheries (Colle and Shireman 1980, Moxley and Langford 1982, Colle et al. 1987, Tate et al. 2003) and other focal taxa, such as waterfowl (Jeske et al. 1993). The influences of hydrilla on fish and wildlife species vary, and are perceived as positive or negative effects depending upon plant density, coverage, location, and duration. Hydrilla can serve as a food source for waterfowl, desirable substrate for invertebrates, and cover for forage fish. Hydrilla can also have negative effects such as influencing: predator prey interactions, water quality impacts that can result in fish kills, avian vacuolar myelinopathy disease in waterfowl or bald eagles, the loss of spawning substrate due to excessive organic deposition, a decline in the local economy, and obstructing navigation. Hydrilla is also expensive to manage. Dense hydrilla mats can influence water quality during summer months causing extreme surface water temperatures and wide fluctuations in pH and dissolved oxygen content (Reiskind et al. 1997). Surface hydrilla mats also provide a

Photo 14. Hydrilla.

substrate for thick growths of filamentous algae that further reduces light and oxygen penetration into the water column. Other exotic and invasive plants have similar effects on substrate composition and populations of fish, wildlife, and native vegetation.

Focal taxa utilizing this habitat include:

- Largemouth bass and black crappie- Use for foraging and cover.
- Waterfowl - Hydrilla is highly attractive to many species of waterfowl, and often determines the number of ducks using the area. All parts of the plant are consumed.
- Wading birds - Wading birds may be attracted to hydrilla mats where they may have concentrated prey densities.
- Herpetofauana - This habitat is used extensively by alligators, softshell turtles, Florida snapping turtles, pig frogs, green treefrogs, and some aquatic salamanders, but is not essential habitat for these species.
- Bald eagle - Attracted to prey species that use this habitat, especially waterfowl.

Within the hydrilla regions, evaluate the benefit to fish and wildlife species before treatment.

Strategies implemented to maintain these habitat characteristics can include but are not limited to: biological, chemical, or mechanical treatment.

PROCESS FOR DEVELOPING HABITAT OBJECTIVES

The OCBWG developed two methods to serve as guiding tools for future management actions in the OCB: a habitat matrix and a Geographic Information System (GIS) habitat analysis. The matrix was developed to capture the professional judgment of taxa specialists on the habitat requirements of their sponsored focal taxa in an easy-to-reference format. The GIS habitat analysis was developed to document habitat conditions at a given point in time and to evaluate the suitability of those conditions for all focal taxa. These tools can be used by managers to judge whether effects of a management action will be negative, positive, or neutral to focal taxa in the system.

HABITAT MATRIX EVALUATION

Each sponsor assessed their focal taxon based on measurable habitat characteristics (metrics) of vegetation, which included: percent of the total lake area for each habitat type, percent area coverage (for SAV, emergent and total vegetation), density, species composition, bottom substrate, location, interspersion and dispersion as measured by the contagion index, and minimum block size. Focal taxa experts then provided recommendations for each metric that defined a range of desirable conditions for their respective taxa. The desired values and/or ranges for the focal taxa were compiled and summarized by habitat type into a tabular format, or habitat matrix. The values in the matrix were then compared to determine where suitable habitat ranges among focal taxon overlap or conflict. An integrated range for each habitat metric was derived by calculating the midpoint of each focal taxon's desirable habitat range, and then selecting the highest and lowest of these midpoints to represent the upper and lower bounds of the integrated range (Figure 2). Exceptions: 1) fractions were rounded to the nearest conservative whole number; and 2) when all or all but one of the focal taxa shared a common value for the upper (or lower) range, and that value was higher (or lower) than the highest (or lowest) midpoint, then that value was used for the upper (or lower) value of the integrated range.

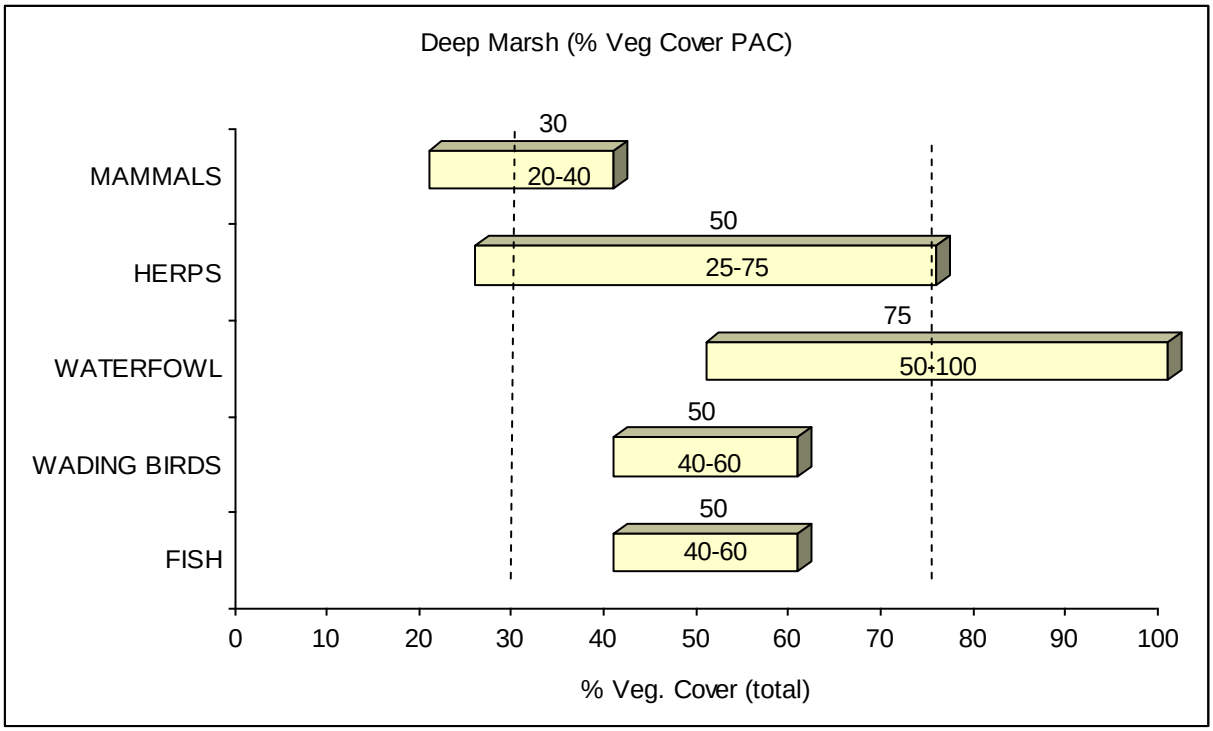

Figure 2. Desired ranges by focal taxa on Orange Lake (numbers within bars) and midpoint (numbers above bars) of percent area coverage for total vegetation within deep marsh. Dashed lines depict the lowest and highest midpoints which were selected to define the integrated range for this metric on this habitat type.

This process was repeated for all habitat types on each lake to derive an "optimum habitat condition" that would maximize habitat suitability for the broadest range of focal taxa possible. These "optimum" ranges were used to establish target ranges and to evaluate the current conditions of the system in relation to habitat preferences of focal taxa. Adhering to these target ranges will ensure the minimum habitat requirements of all focal taxa are met and that no focal taxa are negatively impacted by management activities. Values outside of the target ranges should be considered sub-optimal but not necessarily undesirable.

GIS HABITAT ANALYSIS

Color-infrared digital aerial imagery at a pixel resolution of 1 ft (0.3 m) was acquired for the OCB in April to June of 2007, 2010, 2013, and 2022; September 2016; and July 2019. Vegetation communities were mapped within the littoral zones of Lakes Newnans, Lochloosa, and Orange. Photointerpretation with ground truthing was used to identify and delineate areas (polygons) on the imagery that displayed distinct plant-community signatures. Polygons were classified according to an amended version of the *Florida Land Use, Cover and Forms Classification System* (FLUCFCS, FLDOT 1999). FWC staff performed accuracy assessments to confirm a minimum 90% thematic accuracy of classification (i.e., at least 90% of the independent, field- verified assessment points were correctly coded in the map). Further details of the mapping effort are described in Avineon (2008), AMEC (2014, 2017) , Wood (2020), and WSP (2023). Due to limitations of photography, aerial mapping of SAV was inconsistent and restricted to areas where it grew within 1 ft (0.3 m) of the water surface. At the time of imagery acquisition, SAV was primarily near the water surface in 2007; primarily below the surface in

2010, 2016, 2019, and 2022; and nearly absent in 2013. Therefore, SAV only exhibited a reliable photosignature in 2007 and 2013.

However, hydroacoustic data for SAV were available in 2010 (Remetrix LLC, unpublished data) and 2017, 2019, and 2022 (FWC, unpublished data), and were merged with the littoral vegetation maps to improve accuracy of the final maps. Maps were subsequently reclassified to the habitat classifications used in this document (Appendix C). The littoral vegetation maps provided the framework for further analysis using a Geographic Information System (GIS; ESRI 2013).

Focal taxa sponsors used published data and professional expertise to define preferred habitat conditions, based on compatible habitat characteristics, for focal taxa (Appendix A). This information, along with the data obtained during the mapping projects, was used to develop a GIS analysis for evaluating lake wide habitat conditions that were present at the time of mapping (Mallison and Nagid 2015, Appendix D). The GIS analysis was used individually for each of the focal taxa to identify areas containing aquatic plant communities and coverages that typically provide usable habitat conditions, including high-quality habitat (provides excellent conditions) and acceptable habitat (provides suitable conditions). Results for all focal taxa were combined to evaluate overall lake wide habitat value based on each area's selection as high-quality or acceptable habitat for the group of focal taxa.

ORANGE LAKE

BACKGROUND

Orange Lake is the largest lake in the OCB and contains more diverse and dynamic littoral habitat than Lakes Newnans and Lochloosa (Figure 3). Orange Lake is generally comprised of an extensive perimeter marsh extending lake-ward to a depth of 8 ft (2.5 m), and an extensive interior shallow marsh at depths less than 5 ft (1.5 m; Bryan and Warr 1998). The shallow marsh and deep marsh vary temporally and spatially from a wet prairie to a combination of dense rooted emergent vegetation and floating marsh, dependent on water levels.

Orange Lake is greatly influenced by an altered natural flow regime and drastic changes in water levels. Fluctuating water levels are important for self-maintenance of habitats and fish populations, and many aquatic resources show declines in habitat quality and fish populations without periodic draw-downs and flushing events (Moyer et al. 1996, Estes and Myers 1996). The hydrology of Orange Lake was altered in the 1920s, when Camps Canal was constructed to join Prairie Creek to the River Styx. Additional modifications to the hydrology occurred in 1926 with the construction of Highway 301, and in 1963 with the construction of a fixed-crest weir (56.8 ft NAVD88, maximum elevation) across Orange Creek (Warr et al. 1999). These

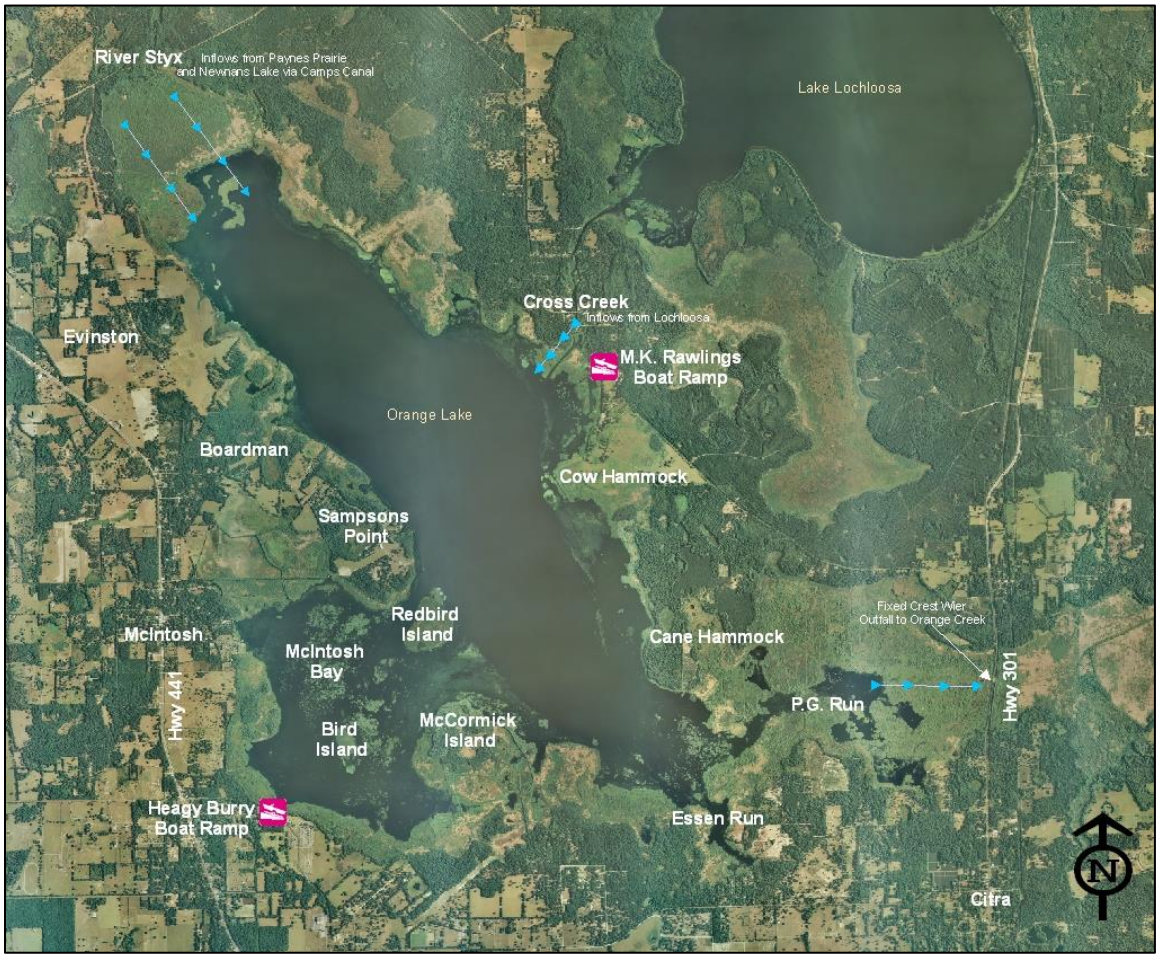

Figure 3. Map of Orange Lake located within Alachua and Marion Counties. Arrows indicate flow direction of surface drainage.

alterations have likely led to accelerated deposition of organic sediments that may change plant community composition and succession, limit permanent rooting of aquatic vegetation, and increase turbidity through re-suspension (Warr et al. 1999).

Climatic cycles such as droughts and floods greatly affect the floral and faunal composition within lake littoral zones (Moyer et al. 1996, Allen and Tugend 2002). Extreme drought events are critical for sediment oxidation and compaction. An average reduction of 1 ft (0.3 m) of sediment thickness was estimated in 2001 on Orange Lake as a result of drought conditions (ECT 2002). Droughts also benefit opportunistic wildlife such as wading birds, due to a greater concentration and accessibility of food resources. Conversely, extreme flooding events are necessary for sediment transport, connectivity between deep marsh and shallow marsh habitats, and light limitation of exotic and invasive aquatic vegetation. Additionally, tussocks formed during drought conditions in traditional deep and shallow marsh areas may become buoyant following inundation (Clark and Reddy 1998), and may subsequently be transported towards the lake's outflow. Following the drought conditions in 2001 and subsequent lake refill there were approximately 5,000 acres (2,025 ha) of tussocks that settled in deep and shallow marsh habitats. The hurricanes of 2004 effectively removed 1,500 acres (600 ha) of tussocks, reclaiming some areas of traditional deep and shallow marsh habitat. An additional 2,500 acres (1,000 ha) of habitat was reclaimed from 2004 to 2006 by herbicide and mechanical control of floating tussocks, also providing benefit to rooted marsh habitat (Mallison et al. 2010).

Exotic and/or invasive aquatic plants also influence the composition and abundance of fish, wildlife, invertebrates, and native plant populations. The exotic submersed aquatic plant hydrilla has been present on Orange Lake since 1974, and is a primary influence upon habitat quality for fisheries (Colle and Shireman 1980, Moxley and Langford 1982, Colle et al. 1987, Tate et al. 2003) and other focal taxa, such as waterfowl (Jeske et al. 1993). Contact herbicides containing diquat and aquathol have been utilized since hydrilla introduction to provide navigation and openings for fishing. Mechanical harvesting was tested in the 1970's to provide navigation in the lake but expense, disposal of material, and slowness of control eliminated it as a viable alternative for hydrilla control. From 1982 to 1996 fluridone proved to be a good tool for hydrilla control until the plant became resistant to this herbicide. Sharp increases in water level provided much needed natural control in 1978, 1983, 1995, and 2001. Heavy feeding on hydrilla by American coot (*Fulica americana*) in 2008 reduced hydrilla coverage by approximately 2,000 acres (800 ha). Water hyacinth has been another major exotic plant problem on Orange Lake since the 1950's when herbicide control operations were first conducted. Water hyacinth annual control efforts have ranged up to 4,100 acres (1,660 ha) per year. The 4,100 acre control efforts in 1984 were atypical. In the last 10 years, water hyacinth control operations have been less than 100 acres (40 ha) per year. The exotic floating species water lettuce has probably been present in Orange Lake longer than water hyacinth. It was not a management problem in Orange Lake until after the hurricanes of 2004. From 1983 to 2003 a total of only 15 acres (6 ha) of water lettuce had been controlled. In late 2004, water lettuce populations begin to expand rapidly. This rapid expansion prompted managers to begin conducting control efforts resulting in 1,514 acres (613 ha) of water lettuce treatment within the next five years. Exotic and invasive vegetation control is an important management concern, and management efforts and overall water quality are interrelated. For more information regarding aquatic plant management on Orange Lake, see Orange and Lochloosa Aquatic Plant Management Summary (Hinkle 1994).

HABITAT OBJECTIVES FOR ORANGE LAKE

Habitat matrix

A habitat matrix was developed for Orange Lake by focal taxa experts who decided on a range of values for the characteristics of each habitat type that best fit their taxon. The habitat matrix and resulting target values were used to establish management guidelines for lake wide habitat composition (Table 1). The habitat matrices for each habitat type define the detailed conditions that maximize habitat suitability for each taxa group and are the foundation from which integrated ranges for specific habitat metrics were developed to provide the broadest range of benefits for all species of fish and wildlife (Tables 2-9).

Table 1. Lake wide proportion (% of total lake area) of habitat types desired by each focal taxon on Orange Lake. Target range for hydrilla is inclusive of other habitat types where hydrilla is present as an embedded component of the overall vegetation community.

Focal taxa	Tree island	Shrub swamp	Shallow marsh	Floating marsh	Deep marsh	Floating island	Open water	*Hydrilla
Fish	0-5	0-5	20-25	0-10	10-20	0-10	40-50	0-40
Wading birds	0-1	5-10	30-40	15-20	1-5	1-5	40-50	NA
Waterfowl	NA	5-10	20-30	NA	10-30	NA	NA	10-100
Herpetofauna	0-1	1-5	20-30	15-30	5-20	1-5	10-50	25-90
Mammals	0.5-5	1-5	20-30	15-20	5-10	1-5	40-60	NA
Target range	0-3	2-8	20-35	5-23	3-20	1-5	30-50	20-58

Tree island

Elevations are typically between 56 and 57 ft NAVD88 with only minimal inundation occurring during high water events. Within the tree island, 50 to 80% vegetative coverage is desirable with special consideration given to established bird colonies that require medium (50%) vegetative cover (e.g., Redbird and Bird Islands; Table 2). Areas of dense vegetation can be maintained for herpetofaunal species where acceptable. Large trees and snags should be maintained to provide potential nesting sites for bald eagles.

Shrub swamp

Water depths are typically 1.5 to 5 ft (0.5 to 1.5 m). Historical coverage has ranged from approximately 60 to 1,000 acres (25 to 400 ha; Woodward 2010/unpublished data, Bryan and Warr 1998) or <10% of the total lake surface area. Within the shrub swamp habitat, 50-75% vegetative coverage is desirable depending on focal taxon (Table 3). A medium to dense canopy (50 to 100%) that is approximately 2 ft (0.6 m) above the surface of the water is important to provide cover for wood ducks. Block size should be at least 0.25 acres and provide a mosaic of vegetated areas within the shrub swamp to create edge and accessibility for wildlife species.

Table 2. Measurable Components: Tree island.

Focal taxa	Total target area (% of lake area)	HABITAT CHARACTERISTICS						
		Total % vegetation coverage	Vegetation density	Preferred vegetation species	Substrate	Location	Contagion index	Block size
Fish	<5%	NA	NA	NA	NA	NA	NA	NA
Wading birds	<1%	50-100%	Medium	Cypress and red maple	NA	NA	30	NA
Waterfowl	NA	NA	NA	NA	NA	NA	NA	N/A
Herpeto-fauna	<1%	50-75%	High (dense)	Cabbage palm, red maple and cypress	loamy soils, sand, and peat	NA	20-40	<0.5 ha
Mammals (round-tailed muskrat)	0.5-5%	NA	NA	NA	NA	NA	NA	NA
Integrated midpoint range	0-3%	50-75%	Medium-dense	Red maple, cypress	NA	NA	20-40	<0.5ha

Table 3. Measurable Components: Shrub swamp.

Focal taxa	Total target area (% of lake area)	HABITAT CHARACTERISTICS						
		Total % vegetation coverage	Vegetation density	Preferred vegetation species	Substrate	Location	Contagion index	Block size
Fish	<5%	NA	NA	NA	NA	NA	NA	NA
Wading birds	5-10%	70-90%	Medium	Willow	NA	NA	30	NA
Waterfowl	5-10%	50-100%	Medium - high	Button bush, wax myrtle, elderberry,	NA	NA	NA	> 0.1 ha
Herpeto-fauna	1-5%	25-50%	High (dense)	Wax myrtle, button bush, willow	Peat, mud, sand	NA	20-40	<0.5 ha
Mammals (round-tailed muskrat)	1-5%	70-90%	High (dense)	Arrowhead, arrow arum	NA	NA	Areas of arrowhead and arrow arum can be managed as forage sites. They need a	NA
Integrated midpoint range	2-8%	37-75%	High (dense)	NA	NA	NA	40-60	0.25-0.5 ha

Shallow marsh

Water depths are typically less than 5 ft (1.5 m). Shallow marsh covered approximately 3,100 acres in 1996 (1,000 to 1,250 ha; Bryan and Warr 1998) or about 20-25% of the total lake surface area. Shallow marshes are common along interior portions of the north, northeast, northwest, and south sections of the lake. Within the shallow marsh habitat, 45 to 65% vegetative coverage is desirable including native SAV (35 to 55%) and rooted emergent (50 to 70%; Table 4). A mosaic of vegetated and non-vegetated areas within the shallow marsh is important to create edge, accessibility and passage for fish and wildlife species. Medium to dense plant coverage is preferred; to include the diversity of the sub-categories and preclude large monocultures.

Table 4. Measurable Components: Shallow marsh.

		HABITAT CHARACTERISTICS								
Focal taxa	Total target area (% of lake area)	Total % vegetation coverage	% vegetation native SAV	% vegetation emergent	Vegetation density	Preferred vegetation species	Substrate	Location	Contagion index	Block size
Fish	20-25%	50-75%	60-80%	50-75%	Med-high (dense)	Maidencane. Monocultures should generally be avoided.	Loamy soils	All quadrants	A diverse, dense community of shallow marsh veg. distributed within the block containing open areas and pockets of sparse veg. 50-70	NA
Wading birds	30-40%	50-100%	50-100%	50-100%	Med-high (dense)	NA	NA	All quadrants	30	NA
Waterfowl	20-30%	30-60%	50-75%	30-60%	Mixed med-high (dense)	Richness of Bryan and Warr sub-habitat types, and to include water shield.	NA	NA	Emergent vegetation should form a mosaic of patches varying in size and shape, with a preferred contagion range of 20-30.	NA
Herpeto-fauna	20-30%	25-75%	25-50%	50-75%	Mixed med-dense (high)	Sawgrass, maidencane, frogs bit. Richness of Bryan and Warr sub habitat types.	Peat,mud, loamy soils	All quadrants	20-40	NA
Mammals (round-tailed muskrat)	20-30%	Moderate (30-60%) varied	5-10%	40-60%	Med-high (dense)	Maidencane preferable, some emurgent pickerelweed acceptable; other veg: arrowhead, knotweed, arrow arum, water lilly.	NA	All quadrants	Dense large areas of maidencane with some knotweed interspersed. Pickerelweed Emurgent, the more contiguous the better. High (60-80)	2-400 ha
Integrated midpoint range	20-35%	45-75%	8-75%	45-75%	Medium-dense	NA	Loamy soils	All quadrants	30-60	2 ha

Floating marsh

Water depths are typically 3 to 10 ft (1 to 3 m). Floating marsh covered approximately 2,000 to 2,500 acres (800 to 1,000 ha) in 1996 (Bryan and Warr 1998) or about 15 to 20% of the total lake surface area. Floating marshes occur throughout Orange Lake, and are particularly common along the southern portion of the south and southwest sections of the lake. Within the floating marsh habitat, dense (80 to 90%) vegetative coverage is desirable (Table 5). Vegetation density along the edge should be composed of emergent plants with 80 to 100 % coverage (round-tailed muskrat). Coverage of floating marsh habitat may decline and/or be transformed into floating islands during extended periods of high water (>56' NAVD88) when wind and wave action from storms cause exposed edges of floating marsh vegetation to separate from the shoreline.

Table 5. Measurable Components: Floating marsh.

		HABITAT CHARACTERISTICS						
Focal taxa	Total target area (% of lake area)	Total % vegetation coverage	Vegetation density	Preferred vegetation species	Substrate	Location	Contagion index	Block size
Fish	<10%	NA	NA	Low floating marsh Frogs bit, pennywort	NA	Only 10% max in deep marsh habitat and <25% in shallow marsh habitat	NA	NA
Wading birds	15-20%	80-100%	Medium	low floating marsh pennywort, knotweed, red temple	NA	NA	30	NA
Waterfowl	NA	NA	NA	NA	NA	NA	NA	NA
Herpetofauna	15-30%	75-90%	High (dense)	Frogs bit, knotweed	NA	NA	20-40	NA
Mammals (round-tailed muskrat)	15-20%	80-100%	High (dense)	Primary arrowhead, knotweed, arrow arum, pickerelweed; secondary spikerush	NA	All quadrants	60	2-400 ha
Integrated midpoint	5-23%	82-90%	Med-dense	NA	NA	Only 10% max in deep marsh habitat and <25% in shallow marsh habitat	30-60	2 ha

Deep marsh

Deep marshes are typically located lake-ward of the shallow marsh/floating marsh complex in water depths of 3 to 8 ft (1 to 2.5 m). Historical coverage has ranged from approximately 600 to 2,000 acres (250 to 850 ha; Bryan and Warr 1998, Woodward 2010/unpublished data) or about 5 to 15% of the total lake surface area. Deep marshes occur throughout Orange Lake, and are particularly common in the West Arm, northeast and east sections, and isolated areas within PG and Essen Runs. Desirable vegetative coverage within the deep marsh habitat includes 40 to 60% total vegetative coverage, SAV 25 to 50%, and rooted emergent 40 to 60 % (Table 6). Medium density is preferred with a mosaic of vegetated and non-vegetated areas to create edge, accessibility and passage for fish and wildlife species.

Table 6. Measurable Components: Deep marsh.

	Total target area (% of lake area)	HABITAT CHARACTERISTICS								
Focal taxa		Total % vegetation coverage	% vegetation native SAV	% vegetation emergent	Vegetation density	Preferred vegetation species	Substrate	Location	Contagion index	Block size
Fish	10-20%	40-60%	40-60%	40-60%	Medium	Spatter-dock, knotgrass, coontail	Loamy soils	All quadrants	Mosaic of knotgrass clumps >1/8 acre and spatterdock clumps >1/16 acre irregularly distributed within the block. With some topped-out.	NA
Wading birds	1-5%	40-60%	40-60%	40-60%	Medium	NA	NA	All quadrants	30	NA
Waterfowl	10-30%	50-75%	20-100%	50-75%	Med-high (dense)	Applies to floating leaved plants only - spatterdock, fragrant water lily, lotus.	NA	NA	Interspersion: n/a Topped out hydrilla would increase attractiveness to waterfowl.	NA
Herpeto-fauna	5-20%	25-75%	25-75%	50-75%	Medium	Spatterdock, coontail, fragrant water lily	Peat, mud	West arm, S, E, NW, PG-run, NE, SW	20-40	NA
Mammals (round-tailed muskrat)	5-10%	20-40%	5-10%	40-60%	Med-high (dense)	Maidencane (primary); Knotgrass (secondary); Knotweed, arrow arum, water lilly	NA	All quadrants	Secondary habiatat for muskrats, maidencane and knotgrass marshes can be intermixed with other preferred veg species. moderate 30-50	2-400 ha
Integrated midpoint range	3-20%	30-63%	8-60%	50-63%	Medium	NA	Peat, loamy	All quadrants	30-40	2 ha

Floating island

Floating islands are highly variable in terms of coverage and distribution. They are typically found in water depths >3 ft (1 m). In 1996, floating islands covered approximately 100 to 200 acres (40 to 80 ha; Bryan and Warr 1998) or <5% of the lake surface area. However, abundance has varied dramatically over time with higher coverage and widespread distribution more common immediately following periods of drought (water level <52.5' NAVD88). Conversely, lake wide coverage of floating islands tends to wain when water levels remain above 56' NAVD88 longer than three years. While floating islands may be present throughout the lake, they are frequently common in the north, east, south, and PG Run sections of the lake. Within the floating island habitat, a medium (30 to 60%) vegetative coverage is desirable with dense vegetation on the edge (80 to 100%; Table 7). A mosaic of vegetated and non-vegetated areas within the floating island is important to create edge, accessibility and passage for fish and wildlife species.

Table 7. Measurable Components: Floating island.

		HABITAT CHARACTERISTICS						
Focal taxa	Total target area (% of lake area)	Total % vegetation coverage	Vegetation density	Preferred vegetation species	Substrate	Location	Contagion index	Block size
Fish	<10%	NA	NA	NA	NA	Only 10% max in deep marsh habitat and <25 in shallow marsh habitat	NA	NA
Wading birds	1-5%	60-80%	Medium	NA	NA	NA	20	NA
Waterfowl	NA	NA	NA	NA	NA	NA	NA	NA
Herpeto-fauna	1-5%	25-75%	Medium	Ludwigia	Peat, mud	NA	NA	<0.5 ha
Mammals (round-tailed muskrat)	1-5%	30-40%	Med-high (dense)	Maidencane, arrowhead, knotgrass, arrow arum	NA	all quadrants	NA	NA
Integrated midpoint range	1-5%	35-70%	Med	NA	NA	Only 10% max in deep marsh habitat and <25 in shallow marsh habitat	20	<0.5 ha

Open water

Open-water habitat on Orange Lake experiences the highest degree of variability of all habitat types described (Table 8). Open-water depths typically range from 5 to 10 ft (1.5 to 3 m). Historical coverage has ranged from approximately 160 up to 8,000 acres (65 to 3,250 ha; Colle et al. 1987, Bryan and Warr 1998, Woodward 2010/unpublished data) or up to 60% of the total lake surface area.

Table 8. Measurable Components: Open water.

Focal taxa	Total target area (% of lake area)	HABITAT CHARACTERISTICS							
		Total % vegetation coverage	% vegetation native SAV	Vegetation density	Preferred vegetation species	Substrate	Location	Contagion index	Block size
Fish	40-50%	0-50%	0-50%	medium	Coontail	NA	NA	NA	NA
Wading birds	40-50%	NA	NA	NA	NA	NA	NA	NA	NA
Waterfowl	NA	NA	NA	NA	NA	NA	NA	NA	NA
Herpeto-fauna	10-50%	25-90%	25-75%	medium	Coontail	Mud	NA	20-40	1-2000 ha
Mammals (round-tailed muskrat)	40-60%	None	NA	Low (sparse)	NA	NA	NA	NA	NA
Integrated midpoint range	30-50%	25-58%	25-50%	Sparse-med	Coontail	NA	NA	NA	NA

Hydrilla

Historical hydrilla coverage has ranged from 2 to 8,000 acres (0.8 to 3,250 ha; Hinkle 1994). On Orange Lake, we apply the FWC hydrilla position with goals for hydrilla control to keep navigation open for public access areas into the lake, keep navigation open within the lake, and keep portions of the lake open for sunfish (*Lepomis* spp.), largemouth bass, and black crappie fishing (Table 9). Herbicide control operations will be limited during periods of peak spawning such as full moon in the spring and during the fall duck hunting season.

Table 9. Measurable Components: *Hydrilla.

Focal taxa	Total target area (% of lake area)	HABITAT CHARACTERISTICS						
		Shallow marsh %	Deep marsh %	Open water %	Vegetation density	Location	Contagion index	Block size
Fish	<40%	0-75%, <50% topped out	0-50%, <10% topped-out	0-25%, <5% topped-out	Medium	NA	Should be incoorporated into other habitat types	NA
Wading birds	NA	0-75%, <50% topped out	0-50%, <10% topped-out	0-25%, <5% topped-out	Dense	NA	Should be incoorporated into other habitat types	NA
Waterfowl	>10 %, all topped-out or within 6 inches of surface from Nov-Feb	NA	NA	NA	Dense	No zone preference	Should be incoorporated into other habitat types	> 5 ha
Herpeto-fauna	25-90%	25-75% 25-50% topped-out	25-75% 25-50% topped-out	25-75% 25-50% topped-out	Medium	NA	Should be incoorporated into other habitat types	1-5 ha
Mammals (round-tailed muskrat)	NA	NA	NA	NA	NA	NA	NA	NA
Integrated midpoint range	20-58%	25-75% 25-50% topped-out	25-75% 25-50% topped-out	0-25% 0-25% topped-out	Med-dense	NA	Should be incoorporated into other habitat types	1-5 ha

**Hydrilla will be managed based on funding, technology, and current conditions.*

RESULTS

GIS habitat analysis

Total mapped coverage of each habitat type was compared to the target ranges from the habitat matrix to evaluate the status of lake wide habitat conditions in Orange Lake during each mapping year (Table 10; Figure 4). When observed coverage fell short of a target range for a habitat type, it was considered deficient (i.e., insufficient area of that habitat type was available to support the focal taxa). When observed coverage exceeded a target range for a habitat type, it was considered excessive (i.e., more than sufficient area of that habitat type was available to support the focal taxa, and the surplus area may be considered for management conversion to a deficient habitat type).

Table 10. Area (acres) and coverage (percentage of the lake, excluding hardwood swamp) for each habitat type mapped in Orange Lake from 2007 to 2022 and target ranges for optimal fish and wildlife habitat. Underlined values were not within the target range. * SAV proportions represent percentages of open-water areas.

	2007		2010		2013		2016		2019		2022		Target range
Habitat type	acres	%	acres	%	acres	%	acres	%	acres	%	acres	%	%
Tree island	200	2%	278	2%	291	2%	322	3%	346	3%	308	2%	0 - 3%
Shrub swamp	1,951	15%	2,045	16%	2,139	17%	2,299	18%	1,848	14%	1,725	13%	2 - 8%
Shallow marsh	2,406	19%	2,138	17%	2,160	17%	1,768	14%	1,980	15%	2,012	15%	20 - 35%
Floating marsh	717	6%	990	8%	6,214	49%	936	7%	547	4%	533	4%	5 - 23%
Deep marsh	529	4%	1,738	14%	656	5%	137	1%	250	2%	548	4%	3 - 20%
Floating island	87	1%	112	1%	51	0%	141	1%	88	1%	74	1%	1 - 5%
Open water	4,054	32%	1,569	12%	1,136	9%	4,480	35%	5,999	46%	3,851	30%	30 - 50%
SAV *	2,889	23%	4,316	60%	19	1%	2,620	36%	1,985	24%	4,490	53%	20 - 58%
Hardwood swamp	540	-	704	-	698	-	607	-	292	-	356	-	n/a

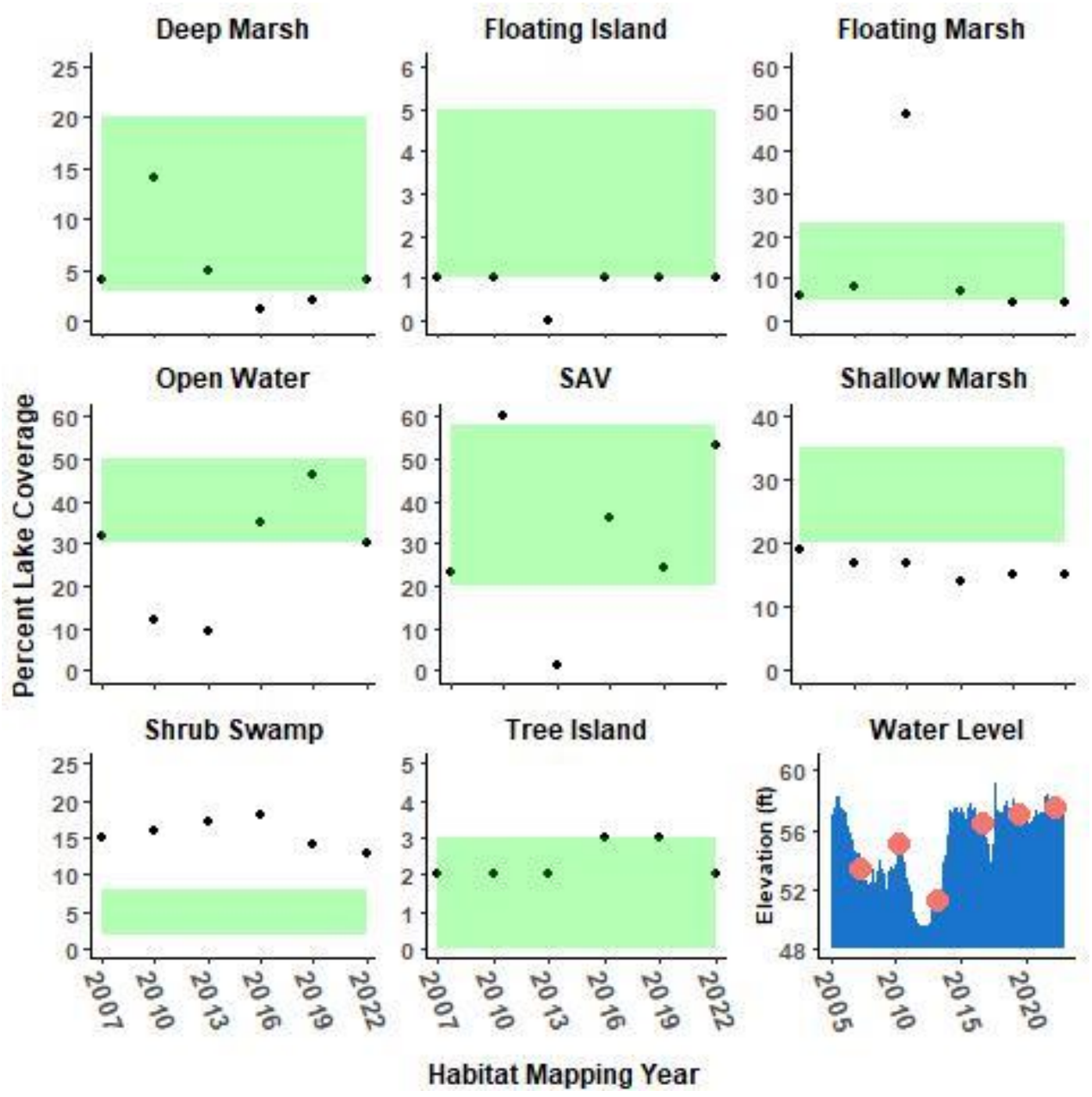

Figure 4. Coverage (percentage of the lake, excluding hardwood swamp) for each habitat type mapped in Orange Lake from 2007 to 2022; and target ranges (shaded area) for optimal fish and wildlife habitat. Daily water levels as recorded by station # 19274284 maintained by the St. Johns River Water Management District with points highlighting dates of individual mapping events.

Mapping results for all years showed an excess of shrub swamp habitat and a shortage of shallow marsh habitat. This is likely a function of woody shrub swamp vegetation encroaching into exposed shallow marsh areas during periods of low water, which is a typical scenario in lake and wetland succession. The bottom sediments in Orange Lake are highly organic and much of the shrub swamp vegetation actually rises up on a buoyant matrix of peat and organic sediment when water levels increase, which effectively reduces the depth of inundation around the stem and root balls of the woody shrubs and small trees. This buoyant marsh phenomenon is a well-documented, almost trademark characteristic of Orange Lake, and plays a major role in the expansion and persistence of woody shrubs and small trees in areas that would otherwise be too deep for woody vegetation to survive. The buoyant nature of the peat laiden substrate actually subverts the function that high water plays in drowning out woody vegetation and restoring herbaceous shallow marsh communities during the course of natural water level fluctuations. This condition has a dramatic effect on the long term composition of nearshore habitat types and active management through habitat conversion is required to achieve the prescribed habitat composition in these areas.

GIS analysis was used to estimate the lake wide area of high-quality, acceptable, and total habitat for each focal taxon on Orange Lake in each mapping year (Table 11; Figure 5; Appendix D).

Alligator foraging

Alligator foraging habitat is generally stable on Orange Lake except during periods immediately following extreme draw downs (Figure 5). Total alligator foraging habitat declined to its lowest documented level (3,173 acres) in 2013 following two successive years of severe drought in 2011 and 2012, a reduction of more than 55% from levels recorded in 2007 (7,699 acres) and 2010 (7,370 acres). However, alligator foraging habitat quickly rebounded to pre-drought levels by 2016 (7,503 acres) and continued to increase through 2022 as coverage reached the highest level recorded so far at 8,769 acres.

Alligator nesting

Alligator nesting habitat on Orange Lake is generally stable and of good quality, averaging 3,998 acres from 2007 to 2022 (Figure 5). The extensive marsh surrounding the perimeter of the lake as well as floating islands provide adequate habitat for alligators to construct their nests made of mounds of vegetation. An increase in nesting habitat (6,056 acres total) was observed in 2013, likely driven by a drastic increase in floating marsh habitat. By 2022, with the increasing water levels, the habitat available for alligator nesting returned close to the average acreage at 3,915 acres.

Herpetofauna

Herpetofauna habitat on Orange Lake is generally stable and of good quality, averaging 10,184 acres from 2007 to 2022 (Figure 5). An increase in high-quality habitat (10,268 acres) was observed in 2013, likely driven by a drastic decrease in open water habitat and increase in marsh habitat, which is preferred by most herpetofauna species. By 2022 however, with the increasing water levels, the total amount of high-quality habitat returned to near 2007 levels at 5,142 acres (Table 11).

Table 11. Total area (acres) of high-quality (HQ) and total (TOT, high-quality plus acceptable) habitat for focal taxa on Orange Lake from 2007 to 2022. Green shade denotes highest value observed per taxon across years, and red shade denotes lowest value observed per taxon across years.

	2007		2010		2013		2016		2019		2022	
Focal taxa	HQ	TOT	HQ	TOT	HQ	TOT	HQ	TOT	HQ	TOT	HQ	TOT
Alligator foraging	4,128	7,699	4,866	7,370	1,586	3,173	4,401	7,503	3,958	8,535	4,896	8,769
Alligator nesting	1,956	2,889	2,173	3,346	4,718	6,056	2,249	3,787	2,489	3,996	2,452	3,915
Herpetofauna	5,017	9,641	5,608	12,233	10,268	12,209	4,876	9,235	4,975	7,762	5,142	10,026
Round-tailed muskrat	1,485	3,384	1,053	4,035	1,413	7,134	1,260	2,750	696	2,681	476	2,902
Wading bird foraging	2	5,083	45	5,354	7	3,393	21	5,107	45	5,967	31	6,393
Wading bird roosting	1,466	3,075	1,633	3,595	1,374	6,418	1,402	3,588	1,446	2,785	1,026	2,672
Ring-necked duck	3,872	5,404	6,219	7,249	151	741	3,434	5,561	2,920	5,652	4,620	6,929
Wood duck	2,192	3,411	3,137	4,082	542	968	1,721	3,063	2,188	3,590	2,773	4,251
Black crappie	4,089	8,429	1,752	8,134	1,142	4,517	4,587	8,667	6,093	9,837	3,956	10,023
Largemouth bass	2,231	5,082	3,233	7,605	81	2,256	1,302	5,072	1,364	4,326	2,482	6,447

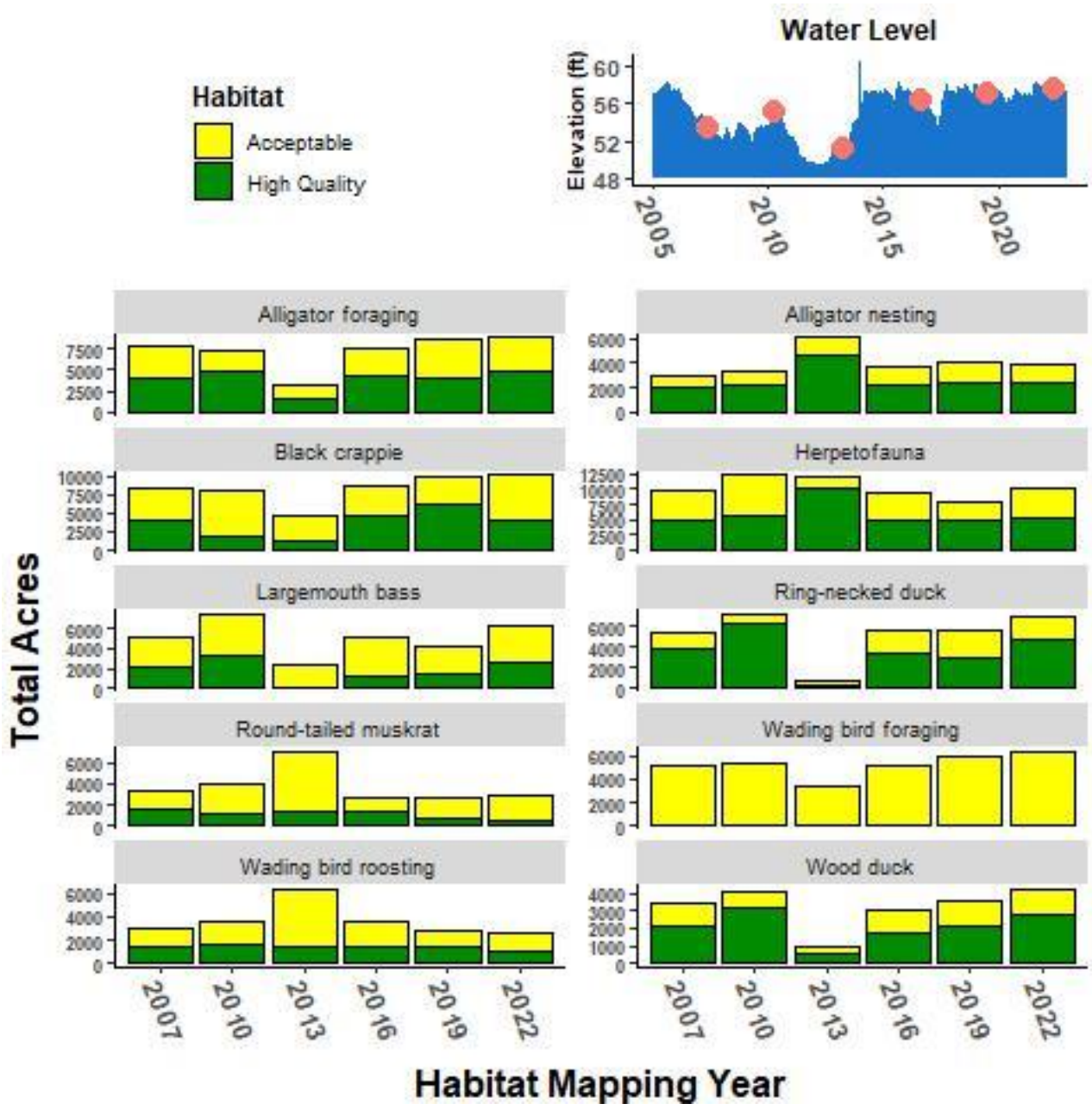

Figure 5. Total area (acres) of high-quality and acceptable habitat for focal taxa on Orange Lake from 2007 to 2022. Daily water levels as recorded by station # 19274284 maintained by the St. Johns River Water Management District with points highlighting dates of individual mapping events.

Round-tailed muskrat
The extensive marsh surrounding the perimeter of the lake typically provides adequate aquatic grasses (e.g., maidencane) on which muskrats forage (along with stems, roots, and seeds of other aquatic plants) and emergent vegetation to which they attach their dome-shaped lodges of plant material. High-quality round-tailed muskrat habitat on Orange Lake remained generally stable, averaging 1,303 acres, from 2007 to 2016 (Figure 5). In 2013, the increase in floating marsh (following drought) greatly increased the amount of acceptable habitat. A decrease in high-quality habitat was observed in 2019 and 2022, likely driven by increasing water levels inundating shallow marsh and reducing access to aquatic grasses or substrate for lodge construction.

Wading bird foraging and roosting
Both wading bird foraging and roosting habitat on Orange Lake are generally stable and of either high or acceptable quality (Figure 5). Average foraging and roosting habitat acreages were 5,216 and 3,689 acres, respectively from 2007 to 2022. The extensive marsh surrounding the perimeter of the lake as well as floating islands provide adequate habitat for all wading bird activities. A large increase in roosting habitat and a decrease in foraging habitat was observed in 2013, likely driven by a drastic increase in floating marsh habitat. Across all years, 2022 saw the highest acreage of foraging habitat at 6,393 acres, and the lowest acreage of roosting habitat at 2,672 acres. However, wading birds need proportionally more foraging habitat than roosting habitat, so the amount of roosting habitat is likely more than adequate for the amount of foraging habitat Orange Lake provides. In addition, Orange Lake supports at least one sizeable wading bird nesting colony along with scattered smaller colonies and lone nests throughout the lake basin.

Ring-necked duck
Ring-necked ducks showed a major decrease in high-quality and acceptable habitat acreage in 2013 while water levels on Orange lake were at a decade low (Figure 5). Since 2013, as the water level increased on Orange lake, open water and SAV increased from a combined 1,155 acres to 7,828 acres (2022). During that time, the total area of ring-necked duck habitat also increased (from 741 acres in 2013 to 6,929 acres in 2022; Table 11).

Wood duck
Wood ducks exhibited similar trends as ring-necked ducks on Orange Lake from 2007 to 2022 (Figure 5). Wood duck habitat was at its lowest observed level in 2013 when water levels were at a low on Orange Lake. Habitat conditions rebounded in the subsequent mapping years, and the coverages of high-quality and acceptable habitat for wood ducks on Orange lake have been steadily increasing.

Largemouth bass
The highest amount of high-quality and acceptable habitat for largemouth bass on Orange Lake occurred in 2010, when SAV/hydrilla (3,789 acres; 30% coverage) and deep marsh (1,738 acres; 14% coverage) habitats were at the highest coverages observed during the five mapping years, and water levels were at an intermediate level (Figure 5). The area then experienced a severe drought and the lake dropped to extreme low levels during 2011 and 2012. The water started to rise in summer 2012 and when the lake was mapped in 2013, almost half of the lake was covered by floating marsh (6,214 acres; 49% coverage), with almost no SAV/hydrilla coverage (19 acres;

<1% coverage) and a lower deep marsh coverage (656 acres; 5% coverage) than observed before the drought. This contributed to the lowest amounts of high-quality (81 acres) and acceptable (2,176 acres) habitats for largemouth bass observed during the five mapping years. The 2016 (5,072 acres) and 2019 (4,326 acres) total habitat for largemouth bass at Orange Lake were at levels comparable to what was observed in 2007 (5,082 acres). However, the amount of high-quality habitat (2016: 1,302 acres; 2019: 1,364 acres) was much lower than what was observed in 2007 (2,231 acres). Much of that is attributed to the lack of SAV/hydrilla habitat and deep marsh habitat coupled with higher open water habitat coverages in the more recent years. Expansion of SAV and deep marsh in 2022 correlated with an increase in high-quality and total largemouth bass habitat, which both ranked at the second-highest level over the 15-year period in 2022.

Black crappie

Orange Lake had relatively similar amount of total habitat available for black crappie in 2007 (8,429 acres), 2010 (8,134 acres), and 2016 (8,667 acres; Figure 5). However, the highest amount of high-quality habitat (6,093 acres) was observed in 2019 and was associated with the greatest amount of open water habitat available (5,999 acres; 46% coverage). The highest amount of total habitat (10,023 acres) was observed in 2022 and was associated with the greatest amount of combined open water, SAV, and deep marsh habitat available (8,375 acres). The lowest amount of high-quality (1,142 acres) and acceptable (3,375 acres) habitat coverages were observed in 2013 after a period of severe drought and low water levels, after which water levels rose, and the lake was dominated by floating marsh (6,214 acres; 49% coverage) at the time of mapping.

Using GIS to identify potential management areas

Mapping and GIS analyses may be used to identify potential management areas, predict the effects of proposed management projects on habitat quality for focal taxa, and monitor trends and changes in plant communities and habitat conditions. This section illustrates how mapping data may be used to identify potential management areas, and introduces the concept of management to change habitat type to fulfill lake wide coverage targets. Multiple alternatives could be devised to reach the end result, where lake wide coverage would meet or approximate targets for all habitat types. However, aquatic plant communities can change substantially within short periods of time. Production and analysis of littoral vegetation maps require 1-2 years to complete. By the time these data become available, actual habitat conditions in some areas of the lake may no longer match the map. Consequently, the actual amount of area appropriate for management may be more or less than the calculated value for each habitat type. These results might be used to guide management toward providing lake wide habitat requirements (to identify general trends or substantial shortcomings), but should not be used to identify absolute area needing management.

The overall habitat value of each area in the lake was evaluated based on each area's selection as usable habitat (high-quality or acceptable habitat value) for focal taxa. Each area scored one point for each taxon that selected the area as acceptable habitat, and two points for each taxon that selected the area as high-quality taxa. Overall habitat value was ranked high for areas that scored more than seven points; medium for areas with six or seven points; and low for areas

scoring less than six points. Areas of open water in the limnetic zone that received a low rank were labeled "low (open water)" to distinguish these areas, which would not be appropriate for management activity. Exceptions:

1. All polygons classified as hardwood swamp or tree island were designated as forested wetland.
2. Areas identified as critical habitat for any of the focal taxa were ranked high overall habitat value (e.g., wading bird rookeries).
3. All mapped areas occurring within the 660 ft (200 m) buffer distance of bald eagle nests active within 5 years were highlighted. Extra caution is needed to ensure that any management activities do not interfere with bald eagle nesting (Oct 1-May 15).

Overall habitat value was used to identify priority sites for management. For example, the area of the lake classified as high overall habitat value, in addition to the area of the lake that would not need any management action (forested wetlands and low open water), decreased from 61% of the lake in 2007, to 52% in 2010, and to 29% in 2013 (Figure 6). Subsequently, this area increased to 58% in 2016, 67% in 2019, and 66% in 2022. In these locations, a maintenance-management approach is appropriate: management activity (if any) should be limited to that needed for maintaining the habitat type and conditions as mapped (e.g., herbicide treatments to prevent invasion or expansion of exotic and invasive vegetation). The area of the lake that received a rank of medium overall habitat value was 16% in 2007, which increased to 26% in 2010, then slightly declined to 25% in 2013, 24% in 2016, 22% in 2019, and 23% in 2022. In these locations, the appropriate approach may include maintenance management either as described above or designed to refine habitat characteristics without changing the habitat type (e.g., to increase or decrease plant coverage within an area without changing plant community structure or dominant vegetation type). Finally, the overall habitat value was ranked low for 23% of the lake in 2007, 22% in 2010, 45% in 2013, 19% in 2016, and 11% in both 2019 and 2022. In these locations, modification management designed to change the habitat type has the greatest potential to improve habitat conditions for the greatest number of focal taxa and the lowest risk of negatively impacting habitat value for any focal taxa.

Potential management areas included all locations that, in the most recent analysis (i.e., 2022), qualified as low overall habitat value and consisted of a habitat type that exceeded its target range (Figure 7). This included 850 acres of shrub swamp (Table 12). Converting 683 acres of this area to a different habitat type would bring the lake wide coverage within the target range for shrub swamp. Shortages of habitat were observed for shallow marsh (535 acres) and floating marsh (33 acres). Strategies for converting shrub swamp to these habitat types would be helpful in achieving lake wide habitat targets. An appropriate primary management objective may be to create 564 acres of shallow marsh and 119 acres of floating marsh from 683 acres of excess shrub swamp within potential management areas. Successful completion of this objective would bring all habitat types within their respective target range. Conversion to shallow marsh may be achieved using herbicides to control woody vegetation and a prescribed-burn regime to prevent succession (Hutchinson and Langeland 2010). Conversion of shrub swamp to shallow marsh was identified as a potential management strategy for all years. The data clearly show that the area of shrub swamp increased steadily from 2007 to 2016, while shallow marsh decreased proportionally (Table 10). Upon completion of the stakeholder driven *Orange Lake Habitat*

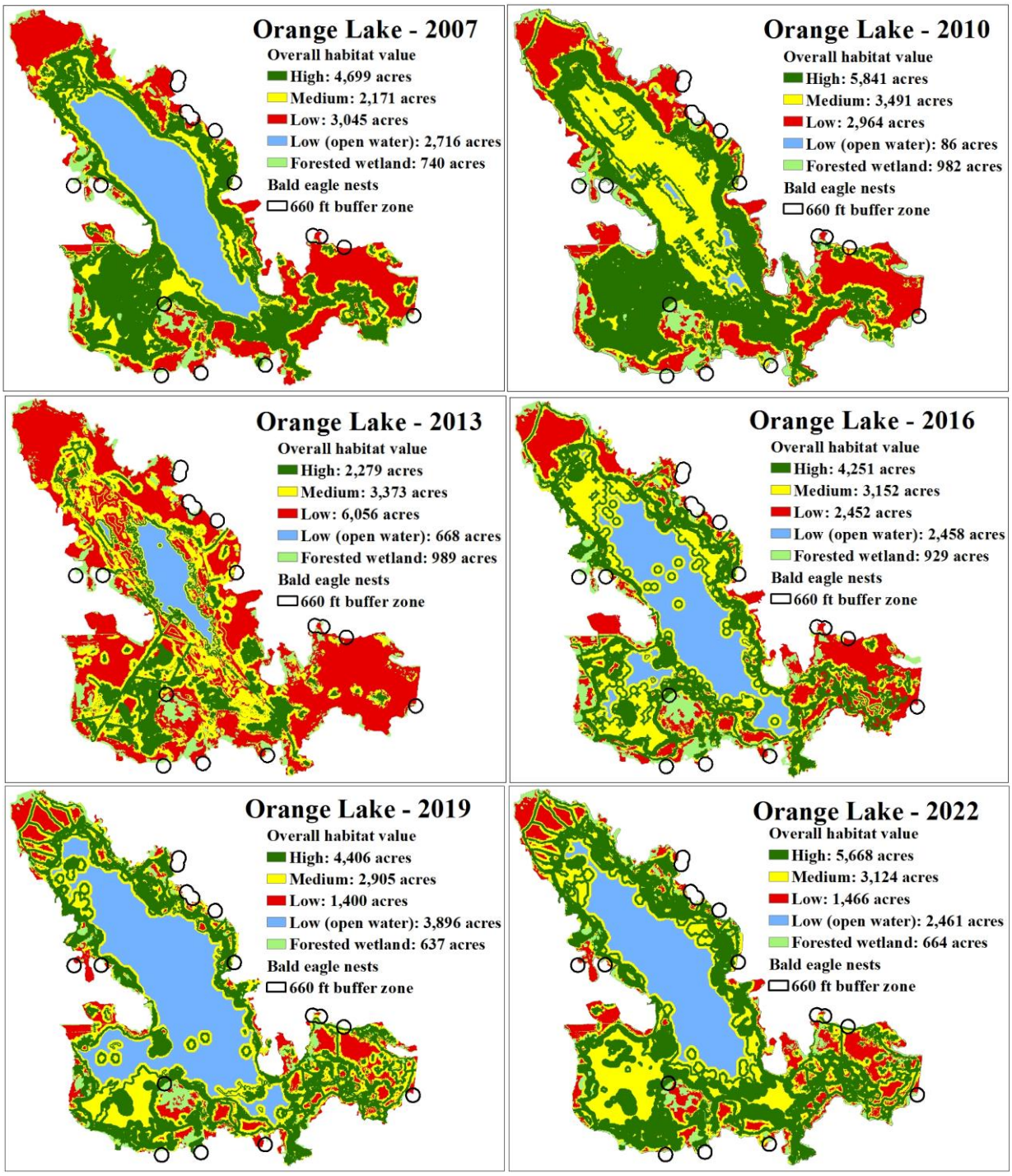

Figure 6. Overall habitat value on Orange Lake from 2007 to 2022, based on GIS analysis and littoral vegetation mapping. High = areas with a habitat value score (HVS) ≥8; medium = areas with a HVS of 6 or 7; low = areas with a HVS ≤5 (with areas of open water in the limnetic zone further specified); and forested wetland = all polygons classified as tree island or hardwood swamp. Areas occurring within 660 ft (200 m) of active bald eagle nests were highlighted bold.

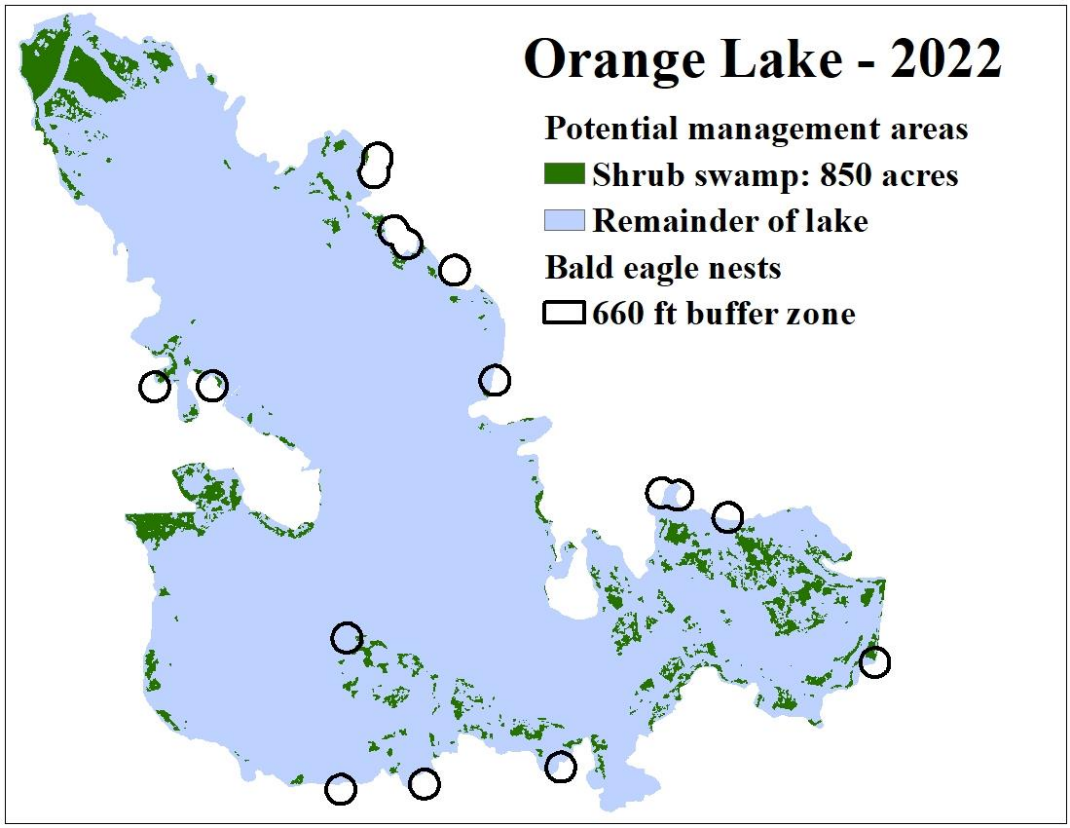

Figure 7. Potential management areas to change the habitat type on Orange Lake based on results in 2022.

Table 12. Area (acres) of each habitat type occurring within the region ranked as low overall habitat value, compared to lake wide coverage on Orange Lake in 2022, and lake wide targets based on habitat matrix results and total area mapped. * area within the low overall habitat value region was included in potential management areas.

Habitat type	Low overall habitat value	Lake wide coverage	Lake wide target area minimum	Lake wide target area maximum
Tree island	0	308	0	391
Shrub swamp *	850	1,725	261	1,042
Shallow marsh	535	2,012	2,605	4,559
Floating marsh	33	533	651	2,996
Deep marsh	<1	548	391	2,605
Floating island	6	74	130	651
Open water	43	3,851	3,908	6,513
SAV / hydrilla	<1	3,976	2,605	7,555
Hardwood swamp	0	356	-	-

Management Plan in 2016, the OCBWG used these data to support a new management strategy that focused on controlling shrub swamp vegetation within the potential management zones referenced above. The goal was to restore shallow marsh habitat, and in some cases deep marsh habitat, while simultaneously reducing the excess coverage of shrub swamp vegetation to attain lake wide habitat targets. As a result, shrub swamp declined to its lowest coverage of all mapping years in 2022, although it still exceeded its target range, and shallow marsh habitat increased by more than 200 acres since 2016. Results from 2019 also warrant limiting control of floating marsh and floating island to that needed for maintaining access until these habitat types expand.

Results of GIS analyses can be used to predict the effects of proposed management on habitat conditions for fish and wildlife. For example, let P_i = the proportion of habitat type i that qualifies as habitat for a focal taxon, A_i = the change in area for habitat type i, and N = the number of habitat types. Then

$$C = \sum_{i}^{N} P_i \times A_i$$

where C = the change in area of qualifying habitat for a focal taxon. For P_i, we used the 2022 percentage of lake wide area per habitat type that qualified as high-quality or acceptable habitat for each of the focal taxa on Orange Lake (Table 13). For A_i, we used the proposed management objectives of reducing shrub swamp by 683 acres and converting to 564 acres of shallow marsh and 119 acres of floating marsh. Achieving management objectives would be expected to increase total habitat by 674 acres for round-tailed muskrat, decrease total habitat by 601 acres for wading bird roosting, and have minimal effect (<200 acres change) on total habitat for remaining focal taxa (Table 13). When developing management plans, these data should be considered to ensure that sufficient habitat is maintained for all focal taxa, in particular for wading bird roosting.

Table 13. Percentage of area per habitat type that qualified as high-quality or acceptable habitat for each of the focal taxa on Orange Lake in 2022, and predicted change in the amount of habitat following proposed management (i.e., conversion of 683 acres of shrub swamp to 564 acres of shallow marsh and 119 acres of floating marsh).

Focal taxa	Open water	Hardwood swamp	Tree island	Shrub swamp	Shallow marsh	Floating marsh	Floating island	Deep marsh	SAV	Change (acres)
Alligator foraging	100%	2%	3%	5%	8%	20%	36%	100%	100%	39
Alligator nesting	0%	0%	73%	84%	82%	96%	99%	0%	0%	6
Herpetofauna	19%	74%	77%	99%	100%	100%	100%	95%	100%	6
Wading bird foraging	16%	45%	55%	69%	67%	35%	100%	38%	61%	-51
Wading bird roosting	0%	79%	100%	100%	1%	62%	0%	0%	0%	-601
Round-tailed muskrat	0%	0%	0%	0%	99%	97%	63%	63%	0%	674
Wood duck	12%	23%	0%	46%	46%	0%	8%	84%	38%	-56
Ring-necked duck	47%	0%	0%	0%	29%	0%	0%	100%	100%	162
Black crappie	100%	11%	18%	28%	33%	64%	85%	100%	100%	74
Largemouth bass	26%	0%	17%	27%	0%	62%	85%	100%	100%	-110

LOCHLOOSA LAKE

BACKGROUND

Lochloosa Lake is the second largest lake in the OCB. Lochloosa Lake is generally comprised of a narrow littoral zone bordered by cypress-dominated forested wetland. Approximately 5,300 acres of the lake (60%) is limnetic zone. The right arm of the lake (2,100 acres, 23%) consists of shallow marsh and shrub swamp with scattered tree islands. Water flows into the lake on the north end primarily from Lochloosa Creek, and exits the lake through Cross Creek into Orange Lake.

HABITAT OBJECTIVES FOR LOCHLOOSA LAKE

Habitat matrix

A habitat matrix was developed for Lochloosa Lake by focal taxa experts who decided on a range of values for each habitat type that best fit their taxon. The habitat matrix and resulting target values were used to establish management guidelines for lake wide habitat composition (Table 14).

Table 14. Lake wide proportion (% of total lake area) of habitat types desired by each focal taxon on Lochloosa Lake. Target range for hydrilla is inclusive of other habitat types where hydrilla is present as an embedded component of the overall vegetation community.

Focal taxa	Tree island	Shrub swamp	Shallow marsh	Floating marsh	Deep marsh	Floating island	Open water	*Hydrilla
Fish	0-5	0-5	10-25	0-10	5-20	0-10	50-75	NA
Wading birds	0-1	5-10	20-30	5-10	5-10	1-5	40-50	NA
Watefowl	NA	1-5	20-30	0-5	5-20	0-5	NA	0-25
Herpetofauna	0-1	1-10	10-30	5-20	5-10	0-1	60-75	0-10
Mammals	0-1	5-10	20-30	10-15	5-10	1-5	40-60	NA
Target range	0-3	2-8	17-30	2-13	5-13	0-5	45-68	0-13

RESULTS

GIS habitat analysis

Total mapped coverage of each habitat type was compared to the target ranges from the habitat matrix to evaluate the status of habitat conditions in Lochloosa Lake during each mapping year (Table 15; Figure 8). In all years, tree island, floating island, and SAV were within their target ranges. In 2007, mapped coverage exceeded the target range for shrub swamp and fell short of the target range for shallow marsh. In subsequent years, these habitat types balanced out to within the target ranges (except for shallow marsh in 2019 and 2022). The reduction of shrub swamp was attributed to management with prescribed fire in the right-arm marsh. Other than open water in 2010, all other habitat types (i.e., tree island, floating marsh, deep marsh, floating

Table 15. Area (acres) and coverage (percentage of the lake, excluding hardwood swamp) for each habitat type mapped in Lochloosa Lake from 2007 to 2022; and target ranges for optimal fish and wildlife habitat. Underlined values were not within the target range. * SAV proportions represent percentages of open-water areas.

	2007		2010		2013		2016		2019		2022		Target range
Habitat type	acres	%	acres	%	acres	%	acres	%	acres	%	acres	%	%
Tree island	7	0%	15	0%	7	0%	16	0%	12	0%	46	1%	0 - 3%
Shrub swamp	738	10%	286	4%	274	4%	336	4%	537	7%	566	7%	2 - 8%
Shallow marsh	1,013	13%	1,452	19%	1,638	22%	1,443	19%	1,128	15%	951	12%	17 - 30%
Floating marsh	132	2%	62	1%	173	2%	95	1%	120	2%	105	1%	2 - 13%
Deep marsh	272	4%	314	4%	511	7%	863	11%	601	8%	871	11%	5 - 13%
Floating island	8	0%	14	0%	8	0%	13	0%	11	0%	11	0%	0 - 5%
Open water	5,146	68%	5,367	71%	4,987	66%	4,816	64%	5,253	69%	5,040	65%	45 - 68%
SAV *	294	5%	0	0%	12	0%	0	0%	2	0%	164	3%	0 - 13%
Hardwood swamp	1,371	-	1,444	-	1,345	-	1,287	-	1,009	-	1,010	-	n/a

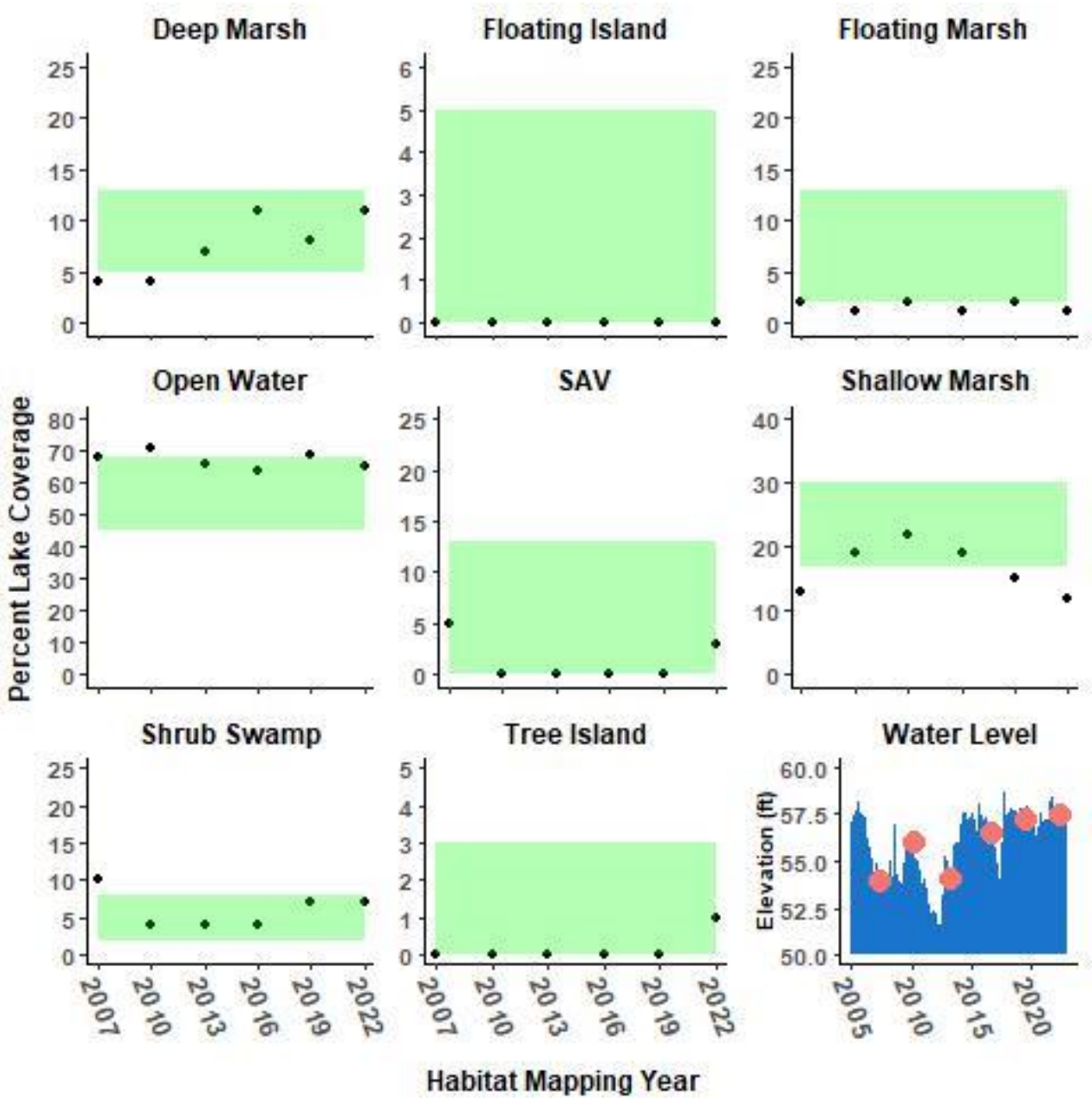

Figure 8. Coverage (percentage of the lake, excluding hardwood swamp) for each habitat type mapped in Lochloosa Lake from 2007 to 2022; and target ranges (shaded area) for optimal fish and wildlife habitat. Daily water levels as recorded by station # 19274284 maintained by the St. Johns River Water Management District with points highlighting dates of individual mapping events.

island, open water, and SAV) were within 1% of their respective target ranges in all years. Because observed coverage of habitat types was very near target range in the most recent map, no conversion of habitat is recommended at this time. Therefore, any management should focus on enhancing habitat quality as described by focal taxa habitat goals (Appendix A).

GIS analysis was used to estimate the lake wide area of high-quality and acceptable habitat for each focal taxon on Lochloosa Lake in each mapping year (Table 16; Figure 9; Appendix E).

Alligator foraging

Habitat suitable for alligator foraging is very stable on Lochloosa Lake, averaging 5,871 acres from 2007 to 2022, with minimum acreage of 5,577 in 2013 and maximum acreage of 6,300 in 2022 (Table 16, Figure 9). The average amount of high-quality habitat for this same time period was 954 acres (16%). Changes in water levels over this time period seem to have had little effect on alligator foraging habitat.

Alligator nesting

Alligator nesting habitat on Lochloosa Lake exhibited a modest increasing trend from 2007 to 2013 and a dramatic spike from 2016 to 2022, increasing nearly 600% over the period of record (Table 16, Figure 9). A significant increase in water level occurred from 2013 to 2017 and was sustained through 2022. The higher water levels improved access to the right-arm marsh, which is dominated by shallow marsh habitat and is an optimal nesting environment for alligators. This explains why total alligator nesting habitat increased sharply during this timeframe, even though lake-wide shallow marsh habitat coverage declined slightly.

Herpetofauna

Herpetofauna habitat has been extremely stable on Lochloosa Lake from 2007 to 2019, averaging 3,691 acres over this time period (Table 16, Figure 9). Habitat types preferred by most herpetofauna species (marsh habitats or marsh interspersed with open water) were very stable during these years. Fluctuations in water levels seem to have had little effect on both total and quality of habitat suitable for herpetofauna on the lake.

Round-tailed muskrat

High quality round-tailed muskrat habitat on Lochloosa Lake was most abundant in 2013 (973 acres; Figure 9; Figure E5). High-quality habitat was present in more moderate, but adequate, amounts in other years, with the exception of 2010 when it comprised just 38 acres. The highest amount of acceptable habitat was in 2010, with 1,496 acres. The sharp decline in high quality habitat documented in 2010 was likely an anomaly caused by a controlled burn that coincided with collection of mapping and GIS data that year. The recent burn made it difficult to identify the dominant species of vegetation in the right-arm marsh at the time the aerial imagery was acquired. Maidencane, which is a high-quality vegetation type for round-tailed muskrats, was likely present in much higher amounts than we were able to verify. Maidencane typically responds very favorably to prescribed fire and would have flourished in the months following the controlled burn.

Table 16. Total area (acres) of high-quality (HQ) and total (TOT, high-quality plus acceptable) habitat for focal taxa on Lochloosa Lake from 2007 to 2022. Green shade denotes highest value observed per taxon across years, and red shade denotes lowest value observed per taxon across years.

	2007		2010		2013		2016		2019		2022	
Focal taxa	HQ	TOT	HQ	TOT	HQ	TOT	HQ	TOT	HQ	TOT	HQ	TOT
Alligator foraging	1,070	5,760	715	5,720	768	5,577	1,053	5,828	1,127	6,043	991	6,300
Alligator nesting	149	236	280	366	465	533	1,284	1,474	1,056	1,374	958	1,370
Herpetofauna	1,540	3,795	1,977	3,615	2,176	3,713	1,849	3,831	2,037	3,453	1,698	3,739
Round-tailed muskrat	356	1,305	38	1,534	973	1,976	746	2,037	408	1,686	240	1,740
Wading bird foraging	0	1,196	1	1,364	6	1,329	0	2,574	16	2,758	7	2,994
Wading bird roosting	78	1,527	44	942	15	1,039	26	1,162	28	1,378	60	1,500
Ring-necked duck	796	1,484	496	1,226	674	1,414	1,033	2,209	939	2,137	1,018	2,254
Wood duck	562	902	571	897	548	872	858	1,488	1,054	1,582	1,119	1,620
Black crappie	5,189	5,907	5,370	5,872	5,138	5,787	5,010	6,242	5,291	6,475	5,049	6,734
Largemouth bass	457	1,070	220	760	263	862	329	1,371	494	1,413	678	1,736

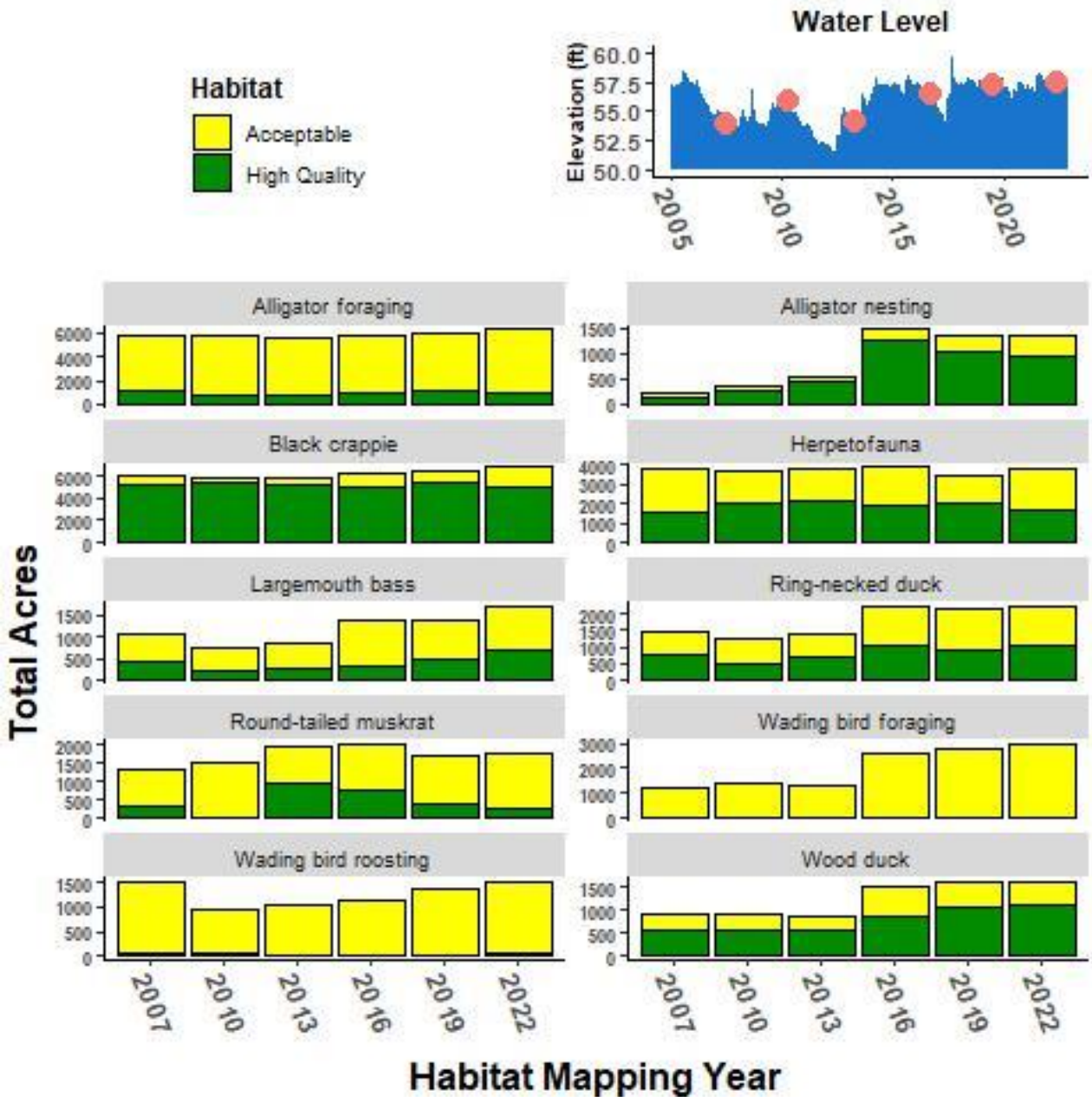

Figure 9. Total area (acres) of high-quality and acceptable habitat for focal taxa on Lochloosa Lake from 2007 to 2022. Daily water levels as recorded by station # 19274284 maintained by the St. Johns River Water Management District with points highlighting dates of individual mapping events.

Wading bird foraging and roosting
Wading bird roosting habitat appears to be relatively stable across years at Lochloosa Lake (average = 1,258 acres). Foraging habitat has more than doubled over the years, from a low of 1,196 acres in 2007 to a high of 2,994 acres in 2022 (Figure 9). This is due largely to the creation and expansion of open water habitat in the right arm marsh, which also produced more edge habitat suitable for wading bird foraging.

Ring-neck duck
From 2007 to 2013, ring-necked duck habitat exhibited stable conditions across high-quality and acceptable habitat coverage on Lochloosa Lake (Figure 9). Since 2013, the habitat quality for ring-neck ducks has slightly and steadily increased, with highest levels of high-quality habitat occurring in 2016 (1,033 acres) and total habitat occurring in 2022 (2,254 acres; Table 16). The highest level of acceptable habitat was observed in 2022 at 1,236 acres.

Wood duck
Wood ducks exhibited similar trends to ring-necked ducks on Lochloosa Lake from 2007 to 2022 (Figure 9). Wood duck habitat displayed stable condition from 2007 to 2013. Habitat was at the lowest observed level over the mapping period in 2013. High-qualityand total habitat peaked in 2022 at 1,119 acres and 1,620 acres, respectively (Table 16).

Largemouth bass
Largemouth bass habitat on Lochloosa Lake was at the lowest observed level in 2010 when deep marsh habitat covered only 314 acres (4% coverage) of the lake and there was no SAV/hydrilla habitat observed (Figure 9). High-quality and total habitat has since been steadily rising in the four subsequent mapping years. The highest coverages of high-quality (678 acres) and total habitat (1,736 acres) were observed for largemouth bass on Lochloosa Lake in 2022, largely due to increases in deep marsh coverage.

Black crappie
Lochloosa Lake has had consistently high values of high-quality habitat for black crappie during all six mapping years (5,010-5,370 acres; Table 16, Figure 9). The amount of high-quality habitat has covered roughly 65-70% of the lake and was driven by the high amount of open water habitat (4,816-5,367 acres; 64-71%) observed throughout the six mapping years.

The overall habitat value of each area in the lake was evaluated based on each area's selection as usable (high-quality or acceptable) habitat for focal taxa (Figure 10), following methods used for Orange Lake. The area of the lake classified as high overall habitat value, in addition to the area of the lake that would not need any management action, was at least 75% in all years and peaked at 83% in 2022. Mapping during the latter period was completed in summer during periods of relatively higher water levels. Standing water was present in the right-arm marsh, particularly in boat trails, and much of this area contributed to higher habitat values for multiple taxa (e.g., alligator foraging and nesting, wading bird foraging, ring-neck duck, wood duck, black crappie, and largemouth bass) and higher overall habitat value ranking in those years.

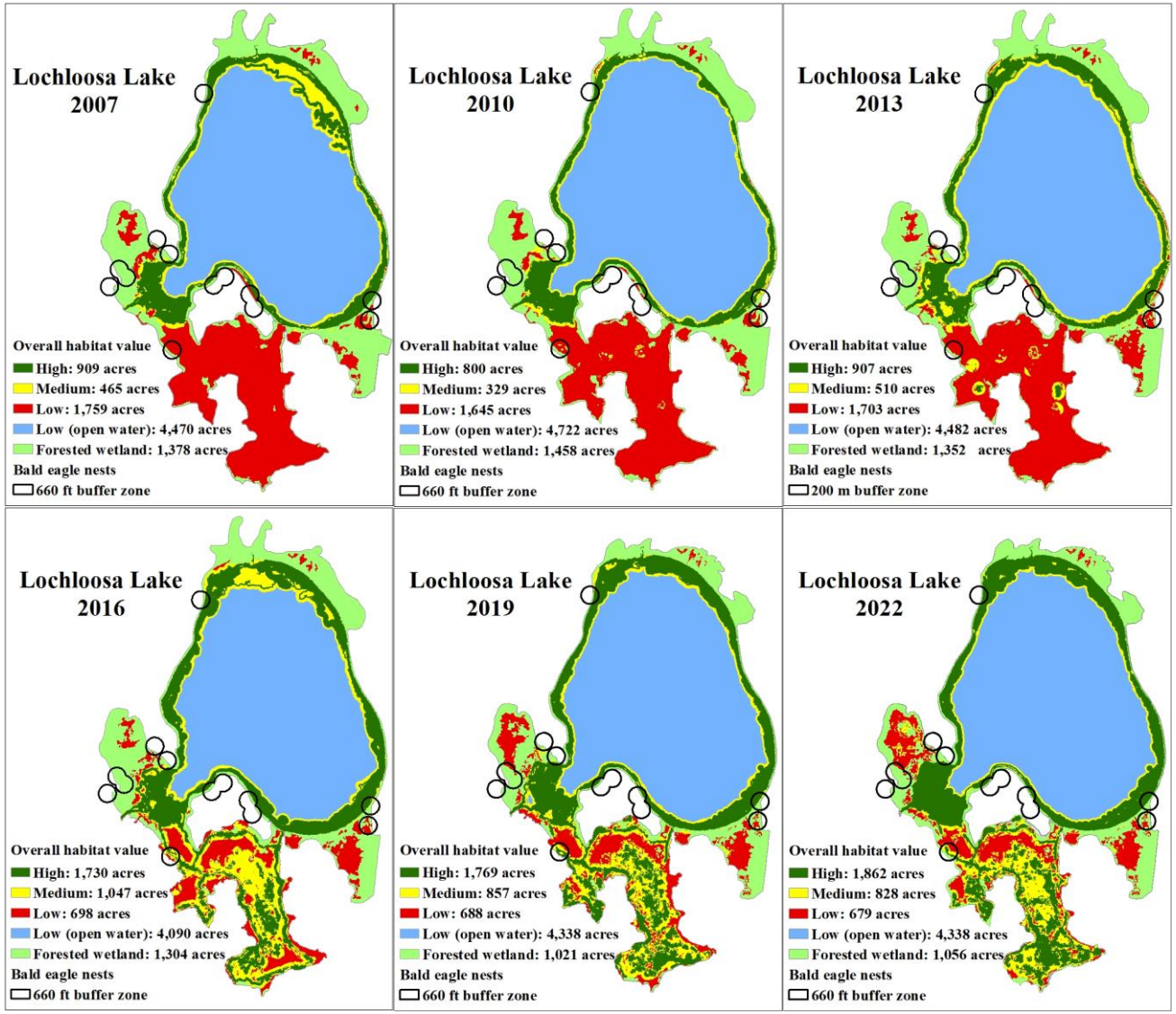

Figure 10. Overall habitat value on Lochloosa Lake from 2007 to 2022, based on GIS analysis and littoral vegetation mapping. High = areas with a habitat value score (HVS) ≥8; medium = areas with a HVS of 6 or 7; low = areas with a HVS ≤5 (with areas of open water in the limnetic zone further specified); and forested wetland = all polygons classified as tree island or hardwood swamp. Areas occurring within 660 ft (200 m) of active bald eagle nests were highlighted bold.

NEWNANS LAKE

BACKGROUND

Newnans Lake is located in the Central Valley region where lakes generally tend to be large, shallow, and eutrophic. The lake is underlain by two geologic formations; the Pliocene Bone Valley formation underlies the northeast portion of the lake, and the Miocene Hawthorne formation underlies the southwest portion of the lake (Brooks 1982). Both formations contain deposits of clayatic sand and phosphoric limestone with interbedded phosphoric pebbles and granules. The lake is approximately 5,000 to 8,000 years old based on sediment core analysis, and is thought to have been eutrophic throughout its history (Holly 1976, Brenner and Whitmore 1998).

Newnans Lake is the third largest lake in the OCB. It has a mean surface area of approximately 7,400 acres with a maximum depth of 12 ft and a mean depth of 4.5 ft (KBN 1993). The drainage area covers approximately 115 mi^2, and supplies the majority of inflow water to the north end of the lake through Hatchet Creek and Little Hatchet Creek. Hatchet Creek is the largest of the inflows, and has several tributaries that drain primarily undeveloped land (e.g., Buck Bay and the Austin Cary Memorial Forest). Little Hatchet Creek enters Newnans Lake through the Gum Root Swamp and drains much of the undeveloped land to the north and east of Gainesville, as well as developed areas such as the Gainesville Regional Airport. Prairie Creek is the single outflow from Newnans Lake at the southern end of the lake. In 1966, a weir was constructed at the outlet to increase water levels. The weir was altered in 1976 with the addition of removable flashboards to provide an option for lake level fluctuations. The weir had a crest of 67 ft above msl and a supplementary low flow orifice designed to discharge 10 ft^3/s at this crest height. However, the flashboards in the weir were permanently removed in 1991 to restore natural lake level fluctuations.

Newnans Lake is generally comprised of a narrow littoral zone bordered by cypress-dominated forested wetland. Consolidated lake sediments are found adjacent to the cypress trees and extend lakeward in patch areas around the perimeter of the lake (Estes et al. 1993). A homogeonous layer of flocculent sediment estimated at an average of 8 ft thick is encountered on the lake bottom away from the vegetation (Forsaith 1916, Byers 1930, Berry 1955, Holly 1976, Gottgens and Crisman 1993, ECT 2002).

Approximately 6,000 acres of the lake (80%) is limnetic zone. The majority of the current emergent vegetation is composed of planted maidencane and giant bulrush, and covers approximately <1% to 5% of the lake area. The Florida Department of Natural Resources Bureau of Aquatic Plant Management (1982-1992) documented hydrilla covering as much as 1,000 acres in 1991, and American lotus covering as much as 250 acres of the lake in 1992. Water hyacinth was documented to cover approximately 800 acres of the lake surface as shore mats and floating islands prior to the 1950s (Byers 1930, Berry 1955). Berry (1955) speculated that the water hyacinth abundance contributed to the flocculent sediments associated with the lake bottom, especially after the first sprayings were made in 1952 with 2,4-D. However, Forsaith (1916) showed that the lake had an extensive mud bottom in the early 20th century.

HABITAT OBJECTIVES FOR NEWNANS LAKE

Habitat matrix

A habitat matrix was developed for Newnans Lake by focal taxa experts who decided on a range of values for each habitat type that best fit their taxon. The habitat matrix and resulting target values were used to establish management guidelines for lake wide habitat composition (Table 17).

Table 17. Lake wide proportion (% of total lake area) of habitat types desired by each focal taxon on Newnans Lake. Target range for hydrilla is inclusive of other habitat types where hydrilla is present as an embedded component of the overall vegetation community.

Focal taxa	Tree island	Shrub swamp	Shallow marsh	Floating marsh	Deep marsh	Floating island	Open water	*Hydrilla
Fish	0-5	0-5	1-10	0-10	1-20	0-10	70-95	NA
Wading birds	0-1	5-10	10-15	5-10	0-5	0-1	NA	NA
Watefowl	NA	1-10	5-20	0-5	5-20	0-5	NA	0-10
Herpetofauna	0-1	2-5	1-5	1-5	1-5	0-1	75-95	0-10
Mammals	0-1	0-5	10-15	10-15	0-5	0-1	NA	NA
Target range	0-3	2-8	3-13	2-13	2-13	0-5	82-95	0-10

RESULTS

GIS habitat analysis

Total mapped coverage of each habitat type was compared to the target ranges from the habitat matrix to evaluate the status of lake wide habitat conditions in Newnans Lake during each mapping year (Table 18; Figure 11). In 2007, mapped coverage was within the target ranges for all habitat types except shallow marsh. In 2019 and 2022, only tree island, floating island, and SAV remained within target ranges; all other habitat types fell short of their target ranges except open water, which exceeded its target range.

GIS analysis was used to estimate the lake wide area of high-quality and acceptable habitat for each focal taxon on Newnans Lake in each mapping year (Table 19; Figure 12; Appendix F).

Alligator foraging

Habitat suitable for alligator foraging on Newnans Lake is stable, although generally not high quality (Table 19, Figure 12). The average total acreage from 2007 to 2022 was 5,857 acres, although the average proportion of high-quality habitat was only 17% of this area (1,010 acres). This is due to the large amount of open water on the lake that extends to surrounding hardwood swamp with little shallow or deep marsh habitat.

Table 18. Area (acres) and coverage (percentage of the lake, excluding hardwood swamp) for each habitat type mapped in Newnans Lake from 2007 to 2022; and target ranges for optimal fish and wildlife habitat. Underlined values were not within the target range.

	2007		2010		2013		2016		2019		2022		Target range
Habitat type	acres	%	acres	%	acres	%	acres	%	acres	%	acres	%	%
Tree island	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0 - 3%
Shrub swamp	197	3%	132	2%	51	1%	26	0%	17	0%	7	0%	2 - 8%
Shallow marsh	30	1%	65	1%	65	1%	41	1%	21	0%	17	0%	3 - 13%
Floating marsh	101	2%	88	1%	178	3%	54	1%	30	1%	18	0%	2 - 13%
Deep marsh	92	2%	19	0%	344	6%	140	2%	78	1%	66	1%	2 - 13%
Floating island	0	0%	0	0%	3	0%	2	0%	0	0%	0	0%	0 - 5%
Open water	5,527	93%	5,654	95%	5,316	89%	5,689	96%	5,811	98%	5,835	98%	82 - 95%
SAV	14	0%	0	0%	8	0%	0	0%	0	0%	0	0%	0 - 10%
Hardwood swamp	189	-	192	-	186	-	199	-	190	-	204	-	n/a

Table 19. Total area (acres) of high-quality (HQ) and total (TOT, high-quality plus acceptable) habitat for focal taxa on Newnans Lake from 2007 to 2022. Green shade denotes highest value observed per taxon across years, and red shade denotes lowest value observed per taxon across years.

	2007		2010		2013		2016		2019		2022	
Focal taxa	HQ	TOT	HQ	TOT	HQ	TOT	HQ	TOT	HQ	TOT	HQ	TOT
Alligator foraging	1,029	5,726	836	5,835	1,364	5,796	1,010	5,893	915	5,943	905	5,949
Alligator nesting	115	324	113	285	204	269	93	122	48	69	34	42
Herpetofauna	438	765	385	696	584	775	265	497	134	403	96	386
Round-tailed muskrat	0	150	2	147	10	244	13	110	0	64	0	51
Wading bird foraging	23	1,445	43	1,241	31	1,482	5	1,231	9	1,131	7	1,115
Wading bird roosting	76	369	77	325	35	192	6	171	7	138	1	99
Ring-necked duck	646	1,398	195	814	949	1,572	509	1,102	536	1,077	531	1,072
Wood duck	732	1,089	622	888	704	1,035	459	727	504	766	533	817
Black crappie	5,534	5,970	5,664	6,030	5,542	6,003	5,794	6,046	5,838	6,078	5,851	6,078
Largemouth bass	282	871	62	584	315	1,049	62	544	179	535	203	502

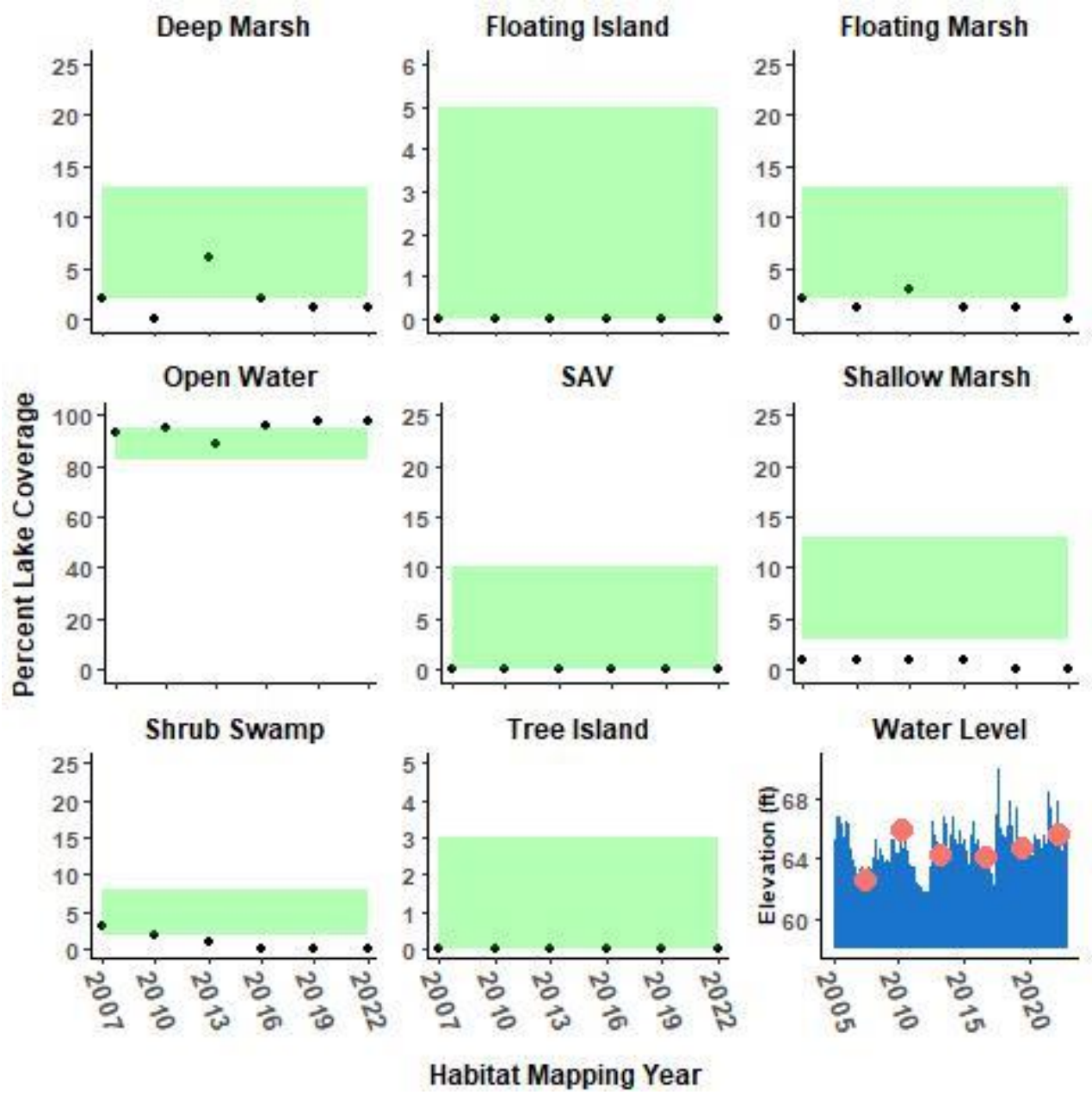

Figure 11. Coverage (percentage of the lake, excluding hardwood swamp) for each habitat type mapped in Newnans Lake from 2007 to 2022; and target ranges (shaded area) for optimal fish and wildlife habitat. Daily water levels as recorded by station # 19274284 maintained by the St. Johns River Water Management District with points highlighting dates of individual mapping events.

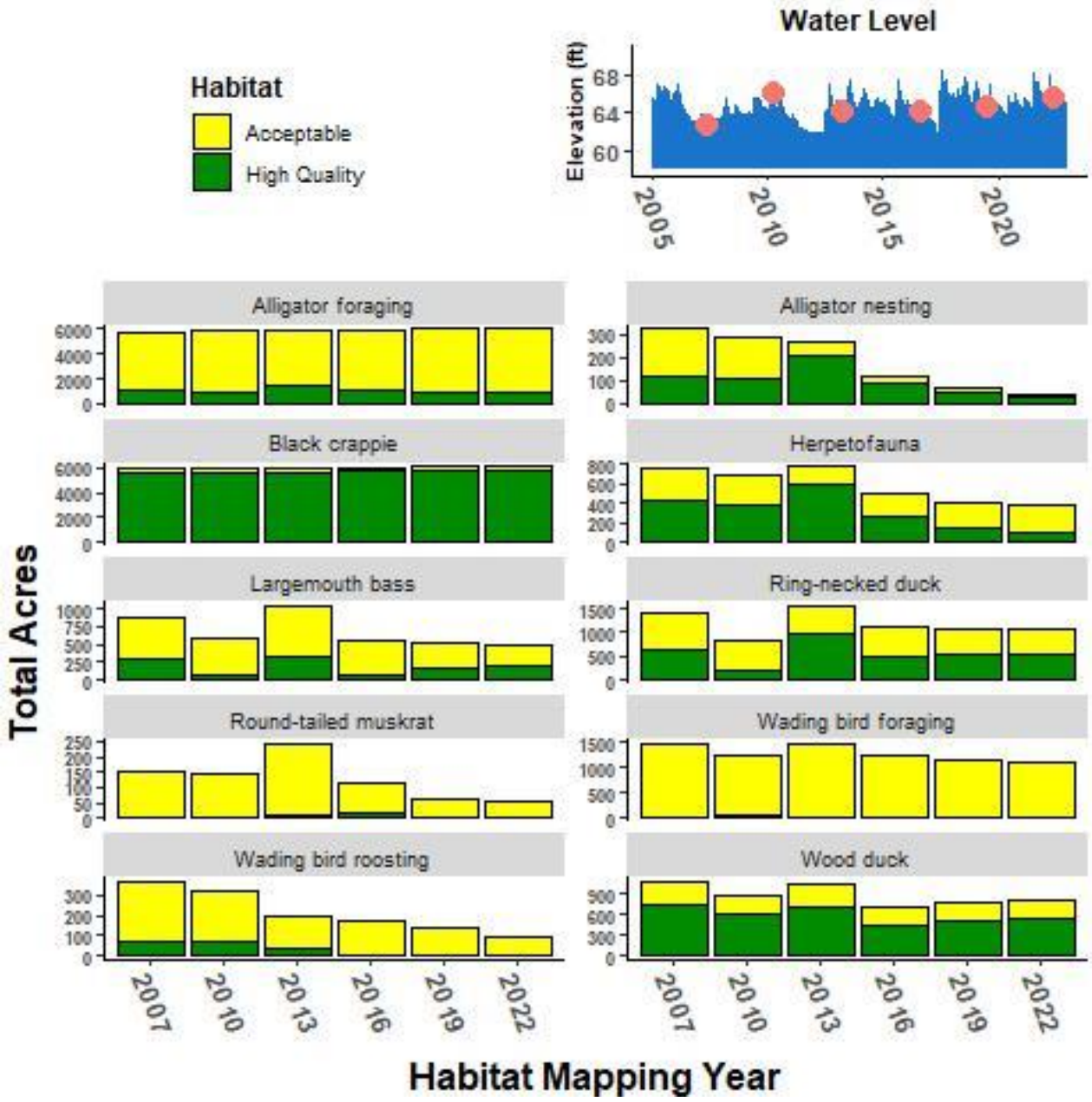

Figure 12. Total area (acres) of high-quality and acceptable habitat for focal taxa on Newnans Lake from 2007 to 2022. Daily water levels as recorded by station # 19274284 maintained by the St. Johns River Water Management District with points highlighting dates of individual mapping events.

Alligator nesting
Nesting habitat for alligators on Newnans Lake is minimal, averaging 185 acres from 2007 to 2022 (Table 19, Figure 12). This is due to the large amount of open water on the lake that extends to surrounding hardwood swamp with little shallow, deep, or floating marsh habitat. Lower water levels in 2013 increased the relative amount of high-quality nesting habitat (204 acres), although total area dropped to 42 acres in 2022 with increasing water levels. From 2007 to 2022, total nesting habitat decreased by 87%.

Herpetofauna
Habitat for herpetofauna on Newnans Lake is stable but relatively low, averaging just 587 acres (Figure 12). Most reptiles and amphibians prefer marsh habitats or marsh interspersed with open water. Newnans Lake is dominated by large amounts of open water that extend to surrounding hardwood swamp, with little shallow, deep, or floating marsh habitat. While aquatic turtles and some salamanders prefer open water habitats, the lack of marsh habitat means large portions of the lake are unsuitable for most reptile and amphibian species. Lower water levels in 2013 increased the relative amount of high-quality and total habitat suitable for herpetofauna, as this corresponded to an increase in marsh habitat. However, this increase was reversed with the return of higher water levels, resulting in just 386 total acres of habitat by 2022 (Table 19).

Round-tailed muskrat
Compared to Orange and Lochloosa Lakes, Newnans Lake supports little high-quality (only up to 13 acres) or acceptable (up to 234 acres) round-tailed muskrat habitat (Table 19). This is due to the limited amount of shallow and deep marsh habitats on the lake, which is where round-tailed muskrats forage and build dens among aquatic grasses and other vegetation. The lowest amount of habitat was observed in 2022, with only 51 total acres, none of which was high quality.

Wading bird foraging and roosting
Compared to the two larger lakes in the Orange Creek Basin, Newnans Lake supports relatively small amounts of wading bird foraging and roosting habitat, especially the latter (Table 19, Figure 12). In addition, overall acreage of both types has generally declined over the years, with 2022 being the lowest total habitat on record for both foraging and roosting habitat. However, the amount of foraging habitat has not declined by the same magnitude as the roosting habitat, which at 99 acres is less than half its peak (369 acres in 2007). A reduction in shrub swamp coverage over the same period may explain the change in roosting habitat.

Ring-necked duck
The greatest amount of high-quality (949 acres) and total habitat (1,572 acres) for ring-necked ducks on Newnans Lake was observed in 2013 (Table 19). The highest acreage of acceptable habitat was observed in 2007. Since 2013, the area of high-quality, acceptable, and total habitat for ring-necked duck has been stable (Figure 12).

Wood duck
Wood duck habitat has been generally stable over the observed mapping years on Newnans Lake, with a slight decrease in area of high-quality, acceptable, and total habitat in most recent years. In 2007, high-quality, acceptable, and total habitat were all at their highest levels (732

acres, 356 acres, and 1,089 acres, respectively; Table 19). In 2016, high-quality and total habitat exhibited the lowest acreage (459 acres, 727 acres respectively). In 2019, acceptable habitat was at its lowest observed acreage over the mapping period at 262 acres.

Largemouth bass

The greatest amount of high-quality (315 acres), acceptable (734 acres), and total habitat (1,049 acres) for largemouth bass on Newnans Lake was observed in 2013 (Figure 12). This was a year after the lake reflooded from an extensive drought and deep marsh habitat (e.g., spatterdock) covered 6% of the lake (344 acres), which is the highest amount observed in the six mapping years. The total amount of habitat available for largemouth bass in the other five mapping years ranged from 502 to 871 acres, while the high-quality habitat has ranged from 62 to 282 acres.

Black crappie

Newnans Lake has had consistently high values of high-quality habitat for black crappie during all six mapping years (5,534-5,851 acres), largely driven by the high proportion of open water habitat (5,316-5,835 acres; 89-98%) during this time (Figure 12).

The overall habitat value of each area in the lake was evaluated based on each area's selection as usable (high-quality or acceptable) habitat for focal taxa (Figure 13), following methods used for Orange Lake. The combined area of wetland forests and locations ranked as low (open water) or high overall habitat value ranged from 91- 95% in all mapping years. The overall habitat value was ranked low for <1% of the lake (<40 acres) in all years.

Composition of habitat types on Newnans Lake was farthest from the targets in the most recent map (2022), with shrub swamp, shallow marsh, floating marsh, and deep marsh falling short of their respective targets and open water exceeding its target (Table 18). Overall habitat value was ranked low for <1% of the lake. This is insufficient area to create enough of the deficient habitat types to bring the lake within range for all habitat types. Therefore, no potential management areas were identified by GIS analyses. In all years, mapped coverage fell short of the target range for shallow marsh and was below the midpoint of the target ranges for all other habitat types except open water. Efforts to improve lake-wide habitat conditions on Newnans Lake must focus on expanding littoral vegetation or SAV. A possible management objective based on 2022 results might be to create shrub swamp (112 acres under target), shallow marsh (161 acres), floating marsh (101 acres), and deep marsh (53 acres) in areas of excess open water to bring all of these habitat types and open water within their respective target ranges. Locations to conduct this work would need to be found in unvegetated (open water) areas where suitable water depth exists.

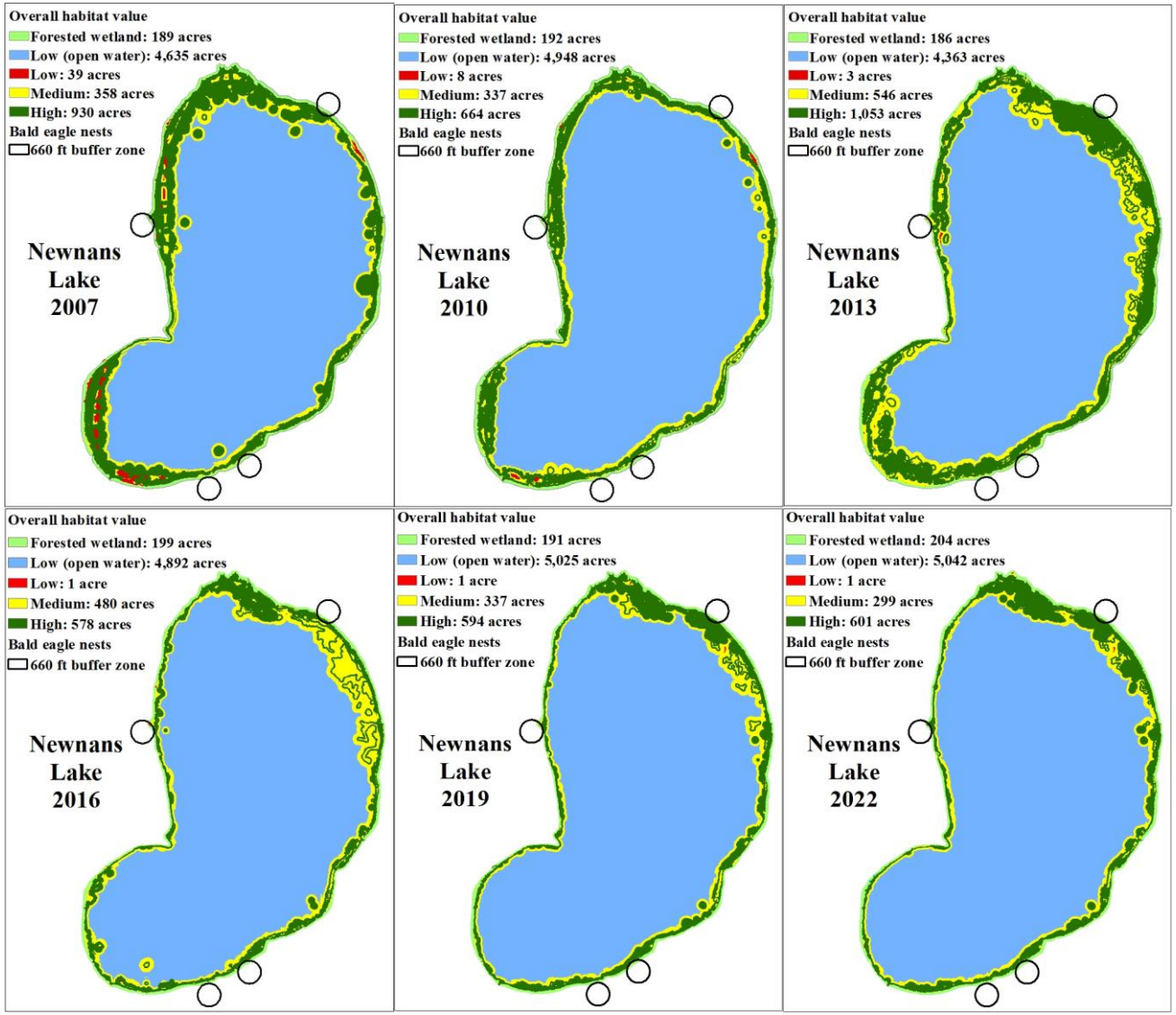

Figure 13. Overall habitat value on Newnans Lake from 2007 to 2022, based on GIS analysis and littoral vegetation mapping. High = areas with a habitat value score (HVS) ≥8; medium = areas with a HVS of 6 or 7; low = areas with a HVS ≤5 (with areas of open water in the limnetic zone further specified); and forested wetland = all polygons classified as tree island or hardwood swamp. Areas occurring within 660 ft (200 m) of active bald eagle nests were highlighted bold.

FUTURE GIS ANALYSIS

Future mapping efforts are scheduled to occur on a three-year interval, pending suitable water levels, so that habitat changes and trends may be documented and incorporated into management planning. Lakes are scheduled to be photographed and mapped in 2025.

GLOSSARY

Basin: Natural depression or relatively low area enclosed by higher land.

Block Size: A discrete spatial area per habitat type that represents the minimum size area required for a focal taxa breeding population.

Burn: The controlled application of fire to naturally occurring vegetative fuels, under specified environmental conditions and following appropriate protocols.

Class: A class includes all patches, polygons, contiguous cells or shapes in a theme, a view or a landscape that have the same value for a given attribute.

Commission: The Florida Fish and Wildlife Conservation Commission as established in the Florida State Constitution Article IV, Section 9.

Contagion Index: Refers to the tendency of patch types to be spatially aggregated, to occur in large, aggregated or "contagious" distributions. Contagion ignores patches per se and measures the extent to which cells of similar class are aggregated. Interspersion, on the other hand, refers to the intermixing of patches of different types and is based entirely on patch (as opposed to cell) adjacencies.

Cookie Cutter: The cookie cutter is a barge/cutting system developed to chop and shred emergent aquatic vegetation, tussocks, floating islands of vegetation and sediment, and to cut openings in shoreline and wetland areas through emergent wetland plants.

Focal Taxa: Species whose requirements for persistence define the attributes that must be present if that landscape is to meet the requirements of species that occur there (Lambeck 1997).

Geographic Information System (GIS): A computer application used to store, view, and analyze geographical information, especially maps.

Harvest: Mechanical removal of aquatic plants, tussocks and/or sediments usually with disposal on an upland site.

Interspersion: This metric is based on patch adjacencies, not cell adjacencies like the contagion index. As such, it does not provide a measure of class aggregation like the contagion index, but rather isolates the interspersion or intermixing of patch types.

Metric: A system of related measures that facilitates the quantification of some particular characteristic.

National Geodetic Vertical Datum (NGVD): A measure of land elevation essentially the same as Mean Sea Level (MSL). NGVD is always given with the date of the datum.

Percent Area Coverage: Referring to the estimated amount of area occupied by aquatic vegetation

Patch: Each individual polygon, contiguous set of cells, or shape is a patch. Each patch has a separate record, or row, in the theme attribute table.

Polygon: Geometric term for a two-dimensional area. This area may be defined as the boundary of an assigned habitat type or geographic feature.

Rotovating: A rotovator is similar to under-water rototiller. The equipment has rototiller-like blades which turn seven to nine inches below the bottom to dislodge and remove roots. The plants and roots can then be removed either manually or with a rake attachment.

Stakeholder: Any organization, governmental entity or individual that has a stake in or may be affected by a given approach to management.

Taxon (plural: **taxa**): A group of (one or more) organisms, which a taxonomist adjudges to be a unit (Wikipedia 2010).

- The Glossary of the International Code of Zoological Nomenclature (1999) defines[1] a "taxon", (pl. taxa), n. A taxonomic unit, whether named or not: i.e., a population, or group of populations of organisms which are usually inferred to be phylogenetically related and which have characters in common which differentiate (q.v.) the unit (e.g. a geographic population, a genus, a family, an order) from other such units. A taxon encompasses all included taxa of lower rank (q.v.) and individual organisms. [...]"

Tussock: Floating island (free-floating) or floating marsh (attached to shoreline vegetation).

LITERATURE CITED

Allen, M.S. and K. Tugend. 2002. Effects of a large-scale habitat enhancement project on habitat quality for age-0 largemouth bass at Lake Kissimmee, Florida. Pages 265-276 *in* D. Phillipp and M. Ridgeway (eds.) Black Bass: Ecology, Conservation and Management. American Fisheries Society, Bethesda, Maryland.

AMEC. 2014. Littoral Vegetation Mapping in Lakes. Amec Foster Wheeler Environment & Infrastructure, Inc. Newberry, Florida. 9 pp.

AMEC. 2017. 2016 Orange Creek Basin Mapping: Littoral Vegetation Mapping in Orange Lake, Lochloosa Lake and Newnans Lake. Amec Foster Wheeler Environment & Infrastructure, Inc. Newberry, Florida. 8 pp.

Avineon, Inc. 2008. Final Project Report for the Mapping Littoral Zones of Freshwater Lakes Project – 2007. Avineon, Inc. Clearwater, Florida. 23 pp.

Berry, F.H.. 1955. Age, growth, and food of the gizzard shad, *Dorosoma cepedianum* (Lesueur), in Lake Newnan, Florida. Master's thesis. University of Florida. Gainesville, Florida.

Brenner, M. and T.J. Whitmore. 1998. Historical sediment and nutrient accumulation rates and past water quality in Newnans Lake. St. Johns River Water Management District. Palatka, Florida.

Brooks, H.K. 1982. Guide to the physiographic divisions of Florida. University of Florida, Institute of Food and Agricultural Sciences, Florida Cooperative Extension Service. Gainesville, Florida

Bryan, J. and K. Warr. 1998. Unpublished data. Report on Floating and Emergent Marsh Vegetation of Orange Lake, Florida. Draft internal report. Environmental Science Division, St. Johns River Water Management District. Palatka, Florida.

Byers, C.F. 1930. A contribution to the knowledge of Florida Odonata. University of Florida Publication. Biological Science Series 1(1):1-327.

Clarke, M.W. and K.R. Reddy. 1998. Analysis of floating and emergent vegetation formation in Orange Lake. Vols 1&2. Final Report.

Colle D.E. and J.V. Shireman. 1980. Coefficients of condition for largemouth bass, bluegill, and redear sunfish in hydrilla infested lakes. Transactions of the American Fisheries Society 109:521-531.

Colle, D.E., J.V. Shireman, W.T. Haller, J.C. Joyce and D.E. Canfield. 1987. Influence of Hydrilla on harvestable sportfish populations, angler use, and angler expenditures at Orange Lake, Florida. North American Journal of Fishery Management 7 (3):410-417.

Environmental and Consulting Technology, Inc. (ECT). 2002. Orange Lake sediment consolidation study, SJRWMD project PO32441. St. Johns River Water Management District. Palatka, Florida.

ESRI. 2013. ArcMap, version 10.2. ESRI. Redlands, California.

Estes, J.R. and R.A. Myers. 1996. Lower Ocklawaha Basin fisheries Investigations: Fish population and fishery response to habitat change. Final Report. Wallop-Breaux F-55-9. 42 pgs.

FLDOT. 1999. Florida Land Use, Cover and Forms Classification System. State of Florida Department of Transportation. 77 pp.

Forsaith, C.C. 1916. A report on some allochthonous peat deposits of FL. Part 1: Topographical. Botanical Gazette 62:32-53.

Florida Fish and Wildlife Conservation Commission (FWC). 2008. Bald Eagle Management Plan (*Haliaeetus leucocephalus)*. Final Report. Florida Fish and Wildlife Conservation Commission. Tallahassee, Florida.

Gottgens, J.F. and T.L. Crisman. 1993. Quantitative impacts of lake-level stabilization on material transfer between water and sediment in Newnans Lake, Florida. Canadian Journal of Fish and Aquatic Science 50:1610-1616.

Gottgens, J.F. and C.L. Montigue. 1987. Orange, Lochloosa, and Newnans Lakes: A survey and preliminary interpretation of environmental research data. Special Publication SJ 87-SP3. St. Johns River Water Management District. Palatka, Florida.

Hinkle, J. 1994. History of hydrilla control in Orange and Lochloosa Lakes. Proceedings of the of the grass carp conference 1994. Edited by William T. Haller, Center for Aquatic and Invasive Plants, University of Florida, Institute of Food and Agricultural Sciences. Gainesville, Florida.

Holly, J.B. 1976. Stratigraphy and sediment history of Newnans Lake. University of Florida Master's thesis. Gainesville, Florida.

Hoyer, M.V., M.D. Netherland, M.S. Allen and D.E. Canfield. 2005. Hydrilla management in Florida: A summary and discussion of issues identified by professionals with future management recommendations. Final document. Florida LAKEWATCH, Department of Fisheries and Aquatic Sciences, University of Florida, Institute of Food and Agricultural Sciences. Gainesville, Florida

Hutchinson, J.T. and K.A. Langeland. 2010. Evaluation of aerial herbicide application for reduction of woody vegetation in a floodplain marsh. Journal of Aquatic Plant Management 48:40-46.

International code of zoological nomenclature. 1999. Fourth edition. International commission on zoological nomenclature. http://www.nhm.ac.uk/hosted-sites/iczn/code/

Jeske, C.W., H.F. Percival and J.E. Thul. 1993. Food habits of wintering ring-necked ducks in Florida. Proceedings of the Southeastern Association of Fish and Wildlife Agencies 47:130-137.

KBN Engineering and Applied Sciences, Inc. (KBN). 1993. Assessing the feasibility of restoring Newnans Lake, phase A. Conceptual engineering report. Prepared for Florida Game and Fresh Water Fish Commission. Gainesville, Florida.

Lambeck, R.J. 1997. Focal species: a multi-species umbrella for nature conservation. Conservation Biology 11:849-856.

Lasi, A. and J. Shuman. 1996. Orange Creek Basin surface water management plan. St. Johns River Water Management District. Palatka, Florida.

Mallison, C.T. , R.K. Stocker , and C.E. Cichra. 2001. Physical and vegetative characteristics of floating islands. Journal of Aquatic Plant Management 39:107–111.

Mallison, C.T. and E.J. Nagid. 2015. Using remote sensing and GIS to quantify fish and wildlife habitat in Orange Lake, Florida. Journal of the Southeastern Association of Fish and Wildlife Agencies 2:64-71.

Mallison, C.T., B.Z. Thompson, and B.V. Jaggers. 2010. Aquatic plant succession following tussock control on Orange Lake, Florida. Journal of Aquatic Plant Management 48:127-130.

Milon, J.W., J. Yingling, and J.E. Reynolds. 1986. An economic analysis of the benefits of aquatic weed control in north-central Florida, with special reference to Orange and Lochloosa Lakes. *In* Annual Report USDA/APS-IFAS/UF: Integrated management of aquatic weeds. Ed. J.C. Joyce. Economics Report 113. University of Florida, Institute of Food and Agricultural Sciences. Gainesville, Florida.

Moxley, D.J. and F.H. Langford. 1982. Beneficial effects of hydrilla on two eutrophic lakes in central Florida. Proceedings of the Southeastern Association of Fish and Wildlife Agencies 36:280–86.

Moyer, E.J., M.W. Hulon, J.J. Sweatman, R.S. Butler, and V.P. Williams. 1996. Fishery responses to habitat restoration in Lake Tohopekaliga, Florida. North American Journal of Fisheries Management 15:591-595.

Pearman, B. et al. 2006. Identifying potential indicators of conservation value using natural heritage occurrence data. Ecological Applications 16:186-210.

Reiskind, J.B., T.V. Madsen, L.C. Van Ginkel, and G. Bowes. 1997. Evidence that inducible C_4-type photosynthesis is a chloroplastic CO_2-concentrating mechanism in *Hydrilla*, a submersed monocot. Plant, Cell and Environment 20:211-220.

Ryti, R.T. 1992. Effects of the focal taxon on the selection of natural resources. Ecological Applications 2:404-410.

Tate, W.B, M.S Allen, R.A Myers, E.J. Nagid and J.R. Estes. 2003. Relation of age-0 largemouth bass abundance to hydrilla coverage and water level at Lochloosa and Orange Lakes, Florida. North American Journal of Fisheries Management 23:251-257.

Warr, K.R., J.C. Bryan, and J.R. Shuman. 1999. Historical perspectives on the hydrology and vegetation in Orange Lake. Draft Internal Report. Environmental Sciences Division, St. Johns River Water Management District. Palatka, Fla.

Warr, K.R. 1999. Orange Lake wetlands management report (draft). Unpublished Report. St. Johns River Water Management District. Palatka, Florida, USA.

Wikipedia. 2010. http://en.wikipedia.org/wiki/Taxon.

WSP. 2023. 2022 Orange Creek Basin Mapping: Littoral Vegetation Mapping in Orange Lake and the Right-Arm Marsh of Lochloosa Lake. WSP Environment & Infrastructure Solutions, Inc. Gainesville, Florida. 8 pp.

Wood. 2020. 2019 Orange Creek Basin Mapping: Littoral Vegetation Mapping in Orange Lake and the Right-Arm Marsh of Lochloosa Lake. Wood Environment & Infrastructure Solutions, Inc. Newberry, Florida. 8 pp.

Woodward, A.R. 2010. Unpublished data. FWC FWRI Wildlife Research - Reptiles and Amphibians.

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APPENDIX A: FOCAL TAXA HABITAT GOALS

HERPETOFAUNA

Allan R. Woodward and Kevin Enge - FWRI Wildlife Research - Reptiles & Amphibians
Blair Hayman – Habitat and Species Conservation - Species Conservation Planning

Background

The Orange Creek Basin (OCB) is composed of a wide range of aquatic habitats that provide important habitat for a variety of reptiles and amphibians. The only broad-based herpetofaunal survey conducted on Orange Lake sampled shallow marsh, deep marsh, floating marsh, shrub swamp, and tree islands using Goin dredges, minnow traps, funnel traps along drift fences, nocturnal frog call surveys, and/or incidental observations (Williams 1997). This study documented only seven anuran species, four caudate species, four turtle species, three lizard species, five snake species, and the American alligator (*Alligator mississippiensis*). Based upon literature (e.g., Carr 1940; Florida Game and Fresh Water Fish Commission 1976; Ashton and Ashton 1988a, 1988b, 1991; Enge 1997) and our knowledge of the area and herpetofaunal use of the habitat types present, we developed a list of potential species and their relative abundance in the seven major vegetative habitat types identified by Bryan and Warr (1998). This list includes 12 anuran species, seven caudate species, 10 turtle species, five lizard species, and 22 snake species (Table A 1). Some of these snake species are terrestrial and do not reside in these habitats, but they will leave adjacent upland habitats and occasionally forage on tree islands or in shallow marsh habitats.

Most reptiles and amphibians prefer marsh habitats or marsh interspersed with open water (Table A 1). Aquatic salamanders are more commonly found in the root systems of floating plants such as frog's bit (*Limnobium spongia*) and water hyacinths (*Eichhornia crassipes*), and to a lesser extent water pennywort (*Hydrocotyle umbellata*) and knotweed (*Polygonum* spp.), than among the submerged stems of emergent plants (P. Moler, pers. comm.). However, the relative use of various plant types has not been well documented.

Additional information on Orange Lake's herpetofauna has been collected during studies of the alligator population. Florida redbelly turtles (*Pseudemys nelsoni*), peninsula cooters *(Pseudemys peninsularis*), stinkpots (*Stenotherus odoratus*), and striped mud turtles (*Kinosternon baurii*) are all commonly preyed on by larger alligators in OCB lakes (Delany and Abercrombie 1986), suggesting they are common. Water snakes (*Nerodia* spp.) and striped crayfish snakes (*Regina alleni*) are occasionally found in stomach contents of larger alligator. The greater siren (*Siren lacertina*) is the only amphibian commonly preyed on by larger alligators in OCB lakes (Delany and Abercrombie 1986). Juvenile alligators occasionally prey on striped crayfish snakes, water snakes, stinkpots, and pig frogs (*Lithobates grylio*; Delany 1990). Florida redbelly turtles commonly lay eggs in alligator nests on Orange Lake, and Florida softshell turtles (*Apalone ferox*) and Florida mud turtles (*Kinosternon subrubrum*) occasionally lay eggs in alligator nests (Deitz and Jackson 1979).

Table A 1. Expected relative abundance of herpetofaunal taxa in various habitats in Orange Lake, Florida. C = Common, U = Uncommon, R = Rare

Taxon	Floating island	Floating marsh	Deep marsh	Shallow marsh	Shrub swamp	Tree island	Open water
Anurans							
Southern toad				U		U	
Florida cricket frog	C	U		C	U	U	
Cope's gray treefrog					R	U	
Green treefrog	U	C	U	C	C	C	C[1]
Squirrel treefrog					R		
Southern spring peeper					U		
Little grass frog				C	R	R	
Eastern narrowmouth toad		U		U	U		
Bullfrog	R	R		U	C	R	
Bronze frog	R	R		U	U	U	
Pig frog	U	C	C	C	C	R	C[1]
Southern leopard frog	U	R	R	C	C	U	
Caudates							
Two-toed amphiuma	U	C	C	C	C	R	C
Dwarf salamander	R	U		C	U	R	
Peninsula newt	U	C	C	C	U	R	R
Narrow-striped dwarf siren	C	C	R	C	R		
Northern dwarf siren				R	U		
Eastern lesser siren	R	C		C	U	R	
Greater siren	C	C	C	C	C	R	C
American alligator	C	C	C	C	C	C	C
Turtles							
Florida snapping turtle	U	U	C	C	U	R	C
Florida chicken turtle				U			
Florida redbelly turtle	U	U	C	C	U	C	C
Peninsula cooter		C		R	C	C	C
Florida box turtle						R	
Yellowbelly slider	C	C	C	C	U	R	U
Striped mud turtle	R	U	R	C	C	R	R
Florida mud turtle	R	R	R	U	U	R	R
Stinkpot	C	C	C	C	C	U	U
Florida softshell	R	U	C	C	U	R	C

Table A 1. Continued.

Taxon	Floating island	Floating marsh	Deep marsh	Shallow marsh	Shrub swamp	Tree island	Open water
Lizards							
Eastern glass lizard				U			
Green anole	U	U		U	C	C	
SE five-lined skink						R	
Broadhead skink						U	
SE five-lined skink						U	
Snakes							
Southern black racer				U	R	R	
Southern ringneck snake				U		R	
Eastern indigo snake						R	
Yellow rat snake	U			R	U	U	
Eastern mud snake	U	U	U	C	C	U	
Eastern hognose snake						R	
Eastern kingsnake				R	R	R	
Scarlet kingsnake						R	
Florida water snake	U	C	C	C	C	U	
Florida green water snake	C	C	U	C	R	R	
Brown water snake					R	R	
Rough green snake					R	R	
Striped crayfish snake	C	C	U	C	U	U	
North Florida swamp snake	C	C	U	C	C	U	
Florida brown snake	U	U		C		R	
Florida redbelly snake						R	
Peninsula ribbon snake	R	R		C	C	R	
Eastern garter snake	R	R		C	U	R	
Eastern coral snake						R	
Florida cottonmouth	C	C	C	C	C	C	
E. diamondback rattlesnake				R		R	
Dusky pigmy rattlesnake				R		R	

[1] Only in topped-out SAV.

Orange Lake has abundant populations of pig frogs and Florida softshell turtles, which are harvested commercially. No reptiles or amphibians considered as rare or endangered by the Florida Committee on Rare and Endangered Plants and Animals are found in Orange Lake (Moler 1992).

The Orange Lake alligator population is one of the densest in Florida (Wood et al. 1985, Woodward and Moore 1990). This is thought to be a product of relatively high nutrient levels (Evert 1999) and a mixture of open water, emergent marsh, floating marsh, and deep marsh, which provide desirable habitat for all sizes of alligators (Woodward et al. 1992). Emergent and

floating marshes, interspersed with deep marsh and open water, provide preferred nesting habitat for alligators (Deitz and Hines 1980, Jennings et al. 1987, Woodward et. al. 1992). Alligators need vegetation with a solid or floating substrate to build a nest (Deitz and Hines 1980). Alligators frequently nest under shrubs and trees in shrub swamps if a permanent source of water is nearby (<328 ft [100 m]). Floating marshes, particularly complex floating marsh are used extensively as nesting sites. Submersed aquatic vegetation (SAV), emergent vegetation, and floating leaf marsh provide a complex habitat for invertebrate and small fish production, which constitute the predominant diet of juvenile alligators (Delany 1990). Small alligators also use shallow habitats for protection against predation from wading birds and larger alligators.

Large alligators forage in deeper water habitats and frequently use open water, deep marsh, and the edge of floating marsh. Adult alligators prefer deeper waters found in open water and deep marsh, where they have good visual connection and adequate water depth for courtship and mating (Vliet 2000). Juvenile and sub-adult alligators readily use topped-out hydrilla (*Hydrilla verticillata*) in open water. Hydrilla is generally good habitat for small alligators because of abundant population of prey species such as small fish, crustaceans, amphibians, and turtles, and it provides cover from larger alligators and other predators. Alligators of all sizes use floating islands, floating marsh, tree islands, and levees for basking. Larger alligators use floating marsh and floating islands as cover from hunters and, presumably, other alligators. No formal studies have been conducted on alligator habitat preference on Orange Lake, but it is generally accepted that alligator populations flourish in aquatic habitats with a mosaic of vegetative communities interspersed with deep marsh or open water habitats.

Focal taxa goals

Achieve and maintain habitat conditions to support the pre-1926 diversity, abundance, and distribution of wetland-dependant herpetofauna in the OCB.

Rationale: Maintaining natural levels of abundance of reptiles and amphibians is important for their long-term conservation. Vegetation communities shape herpetofaunal communities and, therefore, maintenance of natural vegetation communities is important. The general strategy is to manage for habitats that produced the suite of species that were present prior to major modifications to the outflow of water from Orange Lake. These modifications occurred when the causeway near Citra was constructed for the railroad and State Road 21 (later converted to U.S. Highway 301). Management actions within the OCB occur primarily within aquatic habitats, and so these objective focus primarily on wetland-dependant, rather than terrestrial, herpetofauna.

Objectives – based on habitat types

Shallow marsh

Shallow marsh is used by a wide variety of anurans, salamanders, turtles, snakes, and alligators, including primarily terrestrial species that forage or breed in this habitat (Table A 1). Therefore, maintaining historical amounts is important for long-term species conservation. Goals were developed for Orange Lake (Table A 2), Lochloosa Lake, and Newnans Lake (Table A 3).

Table A 2. Herpetofauna focal taxa goals for Orange Lake.

Habitat type	Total target area of habitat type (percent of lake)	Degree of interspersion	Block size	Percent vegetation coverage	Density	Location
Shallow marsh	Alligators: 20–30% Other herpetofauna: 20–30%	Contagion index: 20-40%	use historical block size	Emergent vegetation: 50–75% SAV: 25-50%	Medium	Entire perimeter marsh, P.G. Marsh, River Styx Marsh, McCormick Island Marsh, Twenty Brothers Marsh
Deep marsh	Alligators: 5–20% Other herpetofauna: 5–20%	Contagion index: 20-40%	use natural block size	Emergent vegetation: 50–75% SAV: 25-75%	Medium	S.W. Bay, S.E. Bay, East Side, N.W. side, and P. G. Run
Floating island	Alligators: 1–5% Other herpetofauna: 1–5%	N.A.	<0.5 ha	25–75%	Medium	allow islands to find their own locations
Floating marsh	Alligators: 15–30% Other herpetofauna: 15–30%	Contagion index: 20-40%	use natural block size	75–90%	Dense	same as 1995-96
Shrub swamp	Alligators: 1–5% Other herpetofauna: 1–5%	Contagion index: 20-40%	<0.5 ha	25–50%	Dense	same as 1995-96
Tree island	Alligators: <1% Other herpetofauna: <1%	Contagion index: 20-40%	<0.5 ha	50–75%	Dense	same as current
Open water	Alligators: 40–50% Other herpetofauna: <10%*	Contagion index: 20-40%	1-2,000 ha	SAV: 25-75% Topped-out SAV: 25–75% for alligators, 70–90% for other herpetofauna	Medium	In the natural low areas of the system
SAV	Alligators: 25–75% Other herpetofauna: 25–90%	Contagion index: 20-60%	1-5 ha	SAV: 25-75% Topped-out SAV: 25–75% for alligators, 70–90% for other herpetofauna	Medium	In the natural low areas of the system

*This is dependent on abundance of submerged vegetation (hydrilla, coontail, fanwort, etc.) The greater the amount of submerged vegetation, particularly topped-out hydrilla, the more desirable for herpetofauna.

Table A 2. Continued.

Habitat type	Preferred vegetation species (in order of importance)	Preferred substrate	Focal Taxa Strategies
Shallow marsh	Sawgrass (*Cladium jamaicense*), maidencane (*Panicum hemitomon*), frog's-bit, arrowheads (*Sagittaria* spp.), pickerelweed (*Pontederia cordata*)	Peat, mud, loamy soil	The overall strategy would be to maintain an early successional community, Maintain full range of natural water level fluctuations and natural intervals (5, 10, and 25-year cycles), Restore natural fire frequency, intensity, and seasonality to the extent possible (3–5-year burn cycle), Allow severe fire (peat fire) every 15–20 years, and Spot herbicide treatment of woody vegetation as needed to maintain shallow marsh habitat
Deep marsh	Coontail (*Ceratophyllum demersum*), spatterdock (*Nuphar* spp.), water lily (*Nymphaea* spp.), American lotus (*Nelumbo* spp.)	Peat and mud	Maintain full range of normal water level fluctuations (5, 10, and 25-year)
Floating island	No species preferences	Peat and mud	Maintain full range of normal water level fluctuations (5, 10, and 25-year)
Floating marsh	Frog's bit, knotweed, water pennywort, Cuban bulrush (*Cyperus blepharoleptos*), water primrose (*Ludwigia* spp.)	Water	Maintain full range of normal water level fluctuations (5, 10, and 25-year)
Shrub swamp	Wax myrtle (*Myrica cerifera*), buttonbush (*Cephalanthus occidentalis*), willow (*Salix* spp.)	Peat, mud, 0.1–1.0 m of water underneath shrubs	Maintain a medium-stage successional community of plants, Maintain a full range of normal water level fluctuations (5, 10, 25-year cycles), Restore natural fire frequency, intensity, and seasonality to the extent possible (10-year or longer cycles), and Allow severe burns every 15–20 years
Tree island	Cabbage palm (*Sabal palmetto*), red maple (*Acer rubrum*), bald cypress (*Taxodium distichum*), willow, buttonbush, wax myrtle	Loamy soil, sand, peat	Maintain full range of normal water level fluctuations (5, 10, and 25-year)
Open water	Coontail, fanwort (*Cabomba* spp.)	Mud	Maintain full range of normal water level fluctuations (5, 10, and 25-year), and Mechanical harvesting or herbicide treatment of hydrilla to maintain open trails and interspersion of water and SAVs
SAV	Hydrilla, coontail, fanwort	Mud	Maintain full range of normal water level fluctuations (5, 10, and 25-year), and Mechanical harvesting or herbicide treatment of hydrilla to maintain open trails and interspersion of water and SAVs

Table A 3. Herpetofauna focal taxa goals for total target area of habitat type (percent of lake) on Lochloosa Lake and Newnans Lake.

Habitat type	Lochloosa Lake	Newnans Lake
Shallow marsh	10–30%	1–5%
Deep marsh	5–10%	1–5%
Floating island	<1%	<1%
Floating marsh	5–20%	1–5%
Shrub swamp	1–10%	2–5%
Tree island	<1%	<1%
Open water	60–75% *	75–95% *
SAV	<10%	<10%

*This is dependent on abundance of submerged vegetation (hydrilla, coontail, fanwort, etc.) The greater the amount of submerged vegetation, particularly topped-out hydrilla, the more desirable for herpetofauna.

Deep marsh

Certain focal taxa of species such as aquatic salamanders, turtles, and alligators regularly use deep marsh. Therefore, it is important to maintain historical amounts of this habitat for long-term species conservation.

Floating islands

Floating islands are potentially used by a wide variety of herpetofauna, although relatively little is known regarding actual usage. Maintaining a natural abundance and distribution of floating islands will help with long-term species conservation.

Floating marsh

Floating marshes are used by a wide variety of semi-aquatic and aquatic herpetofauna. Alligators extensively use complex floating marsh for nesting and other types of floating marsh are used for basking. Maintaining a historical amount of floating marsh will aid in the conservation of natural species diversity and abundance.

Shrub swamp

This habitat is not particularly important for most herpetofaunal species, although it is potentially used by a wide variety of species, including treefrogs and arboreal snakes. The shrub swamps being considered are situated within the OCB and are therefore somewhat depauperate in species. If shrub swamps situated adjacent to upland habitats were included, more species would be expected to use this habitat type, including species that rarely use existing habitat types in the OCB. Maintaining small amounts of this habitat will aid in conserving species diversity.

Tree islands

This habitat is not particularly important for most aquatic herpetofaunal species, except as nesting areas for alligators, turtles and snakes. However, tree islands situated along the perimeter of the lake could potentially be used by a wide variety of species, including terrestrial or arboreal species (including lizards) that are rare in other habitat types, which are primarily aquatic. Maintaining small amounts of this habitat will aid in conserving species diversity.

Open water

This habitat is used extensively by alligators, softshell turtles, common snapping turtles, and perhaps some aquatic salamanders, but is not essential habitat for these species. The important objective is to maintain as much marsh/open water edge as possible. Maintenance of this habitat will help conserve natural species diversity and abundance.

SAV

This habitat is used extensively by alligators, frogs, snakes, and aquatic salamanders. SAV is a rich sources of prey, and hydrilla provides basking sites and buoyancy for resting at the water surface. Maintenance of this habitat can enhance population densities of alligators and other herpetofaunatiles. Because hydrilla is an exotic, it is not essential for the long-term conservation of natural species diversity and abundance.

Literature cited

Ashton, R. E., Jr. and P. S. Ashton. 1988a. Handbook of reptiles and amphibians of Florida. Part one: the snakes. Revised edition. Windward, Miami, Florida. 176pp.

Ashton, R. E., Jr. and P. S. Ashton. 1988b. Handbook of reptiles and amphibians of Florida. Part three: the amphibians. Windward, Miami, Florida. 191pp.

Ashton, R. E., Jr., and P. S. Ashton. 1991. Handbook of reptiles and amphibians of Florida. Part two: lizards, turtles and crocodilians. Revised edition. Windward, Miami, Florida. 191pp.

Bryan, J. and K. Warr. 1998. Unpublished data. Report on Floating and Emergent Marsh Vegetation of Orange Lake, Florida. Draft internal report. Environmental Science Division. St. Johns River Water Management District, Palatka, FL.

Carr, A. F., Jr. 1940. A contribution to the herpetology of Florida. University of Florida Publications, Biological Sciences 3:1–118.

Deitz, D. C. and D. R. Jackson. 1979. Use of American alligator nests by nesting turtles. Journal of Herpetology 13:510–512.

Deitz, D. C. and T. C. Hines. 1980. Alligator nesting in north-central Florida. Copeia 1980:249–258.

Delany, M. F. 1990. Late summer diet of juvenile American alligators. Journal of Herpetology 24:418–421.

Delany, M. F. and C. L. Abercrombie. 1986. American alligator food habits in north central Florida. Journal of Wildlife Management 50:348–353.

Enge, K. M. 1997. Habitat occurrence of Florida's native amphibians and reptiles. Florida Game and Fresh Water Fish Commission Technical Report No. 13, Tallahassee, Florida. 44pp.

Evert, J. D. 1999. Relationships of alligator (*Alligator mississippiensis*) population density to environmental factors in Florida lakes. Ms. Thesis. University of Florida, Gainesville, Florida. 122pp.

Florida Game and Fresh Water Fish Commission. 1976. Cross Florida Barge Canal restudy report: wildlife study. Volume I. Section IV: existing environmental setting. Department of the Army Corps of Engineers, Jacksonville, Florida. 217pp.

Jennings, J. L., H. F. Percival, and C. L. Abercrombie. 1987. Habitat variables affecting nesting success of the American alligator in Florida. Proceedings of Annual Conference of Southeast Association of Fish and Wildlife Agencies. 41:334–342.

Moler, P. E. 1992. Amphibians and reptiles. Vol. III, Rare and endangered biota of Florida. University Press of Florida, Gainesville. 291pp.

Vliet, K. A. 2000. Courtship behavior of American alligators, *Alligator mississippiensis*. Pages 383-408 *in* G. C. Grigg, F. Seebacher, and C. E. Franklin, eds., Crocodile Biology and Evolution. Surrey Beatty & Sons, Chipping Norton, Australia.

Williams, G. 1997. Wildlife usage of floating and emergent vegetation communities in Orange Lake. Final Report on Phase II: January–September 1997. Submitted to St. Johns River Water Management District, Palatka, Florida. Department of Wildlife Ecology and Conservation, University of Florida, Gainesville, Florida. 88pp.

Wood, J. M., A. R. Woodward, S. R. Humphrey, and T. C. Hines. 1985. Night counts as an index of American alligator population trends. Wildlife Society Bulletin 13:262-273.

Woodward, A. R., and C. T. Moore. 1990. Statewide alligator surveys. Final Report. Florida Game and Fresh Water Fish Commission, Tallahassee. 24pp.

Woodward, A. R., C. T. Moore, and M. F. Delany. 1992. Experimental alligator harvest. Final Report. Florida Game and Fresh Water Fish Commission, Tallahassee, Florida. 118pp.

MAMMALS

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Summary

Several mammal species occur in the OCB (Table A 4) of which, the round-tailed muskrat (*Neofiber allenii*), marsh rabbit (*Sylvilagus palustris*), rodents including cotton rats (*Sigmodon hispidus*), as well as shrews (*Sorex* spp.) will all be affected by management activities occurring in the OCB. All of these species contribute to nutrient cycling being foragers of grain and insects and providing a prey base for predatory birds and reptiles. The goals outlined herein are for the round-tailed muskrat which is not listed in Florida but is threatened in Georgia.

Background

Round-tail muskrats are found throughout Florida and extreme southern Georgia in shallow freshwater marshes characterized by sandy bottoms and stands of maidencane and southern cutgrass (*Leersia hexandra*; Birkenholz 1972). They construct dome-shaped lodges of aquatic plants, similar to that of the beaver (*Castor canadensis*), attaching them to emergent vegetation (Birkenholz 1972). Feeding platforms are also built near the lodge, consisting of a pad of plant material (Birkenholz 1963). Aquatic grasses make up the bulk of its diet but stems, roots, and seeds are also eaten. Major predators of the round-tail muskrat are herons, owls, hawks, snakes, and bobcats. Population densities can range from 25-100 individuals per acre in good habitat (University of Georgia 2007). Droughts and flooding are common hazards faced by the round-tailed muskrats, leading to periodic population fluctuations (Birkenholz 1963) so stabilized water levels positively influence their abundance (Hafner et al. 1998).

Focal taxa goals

Round-tailed muskrat - Provide high quality emergent wetland habitat to enhance the abundance and distribution of round-tailed muskrat in the OCB.

Other mammals – Provide high quality edge habitat (extensive 3D structure, forage) to enhance the stability of these populations and increase the distribution of these organisms.

Objectives – based on habitat types

Shallow marsh

This type should cover between 20–30% of Orange Lake (Table A 5) and Lochloosa Lake (Table A 6), and 10-15% of Newnans Lake (Table A 6). This habitat is directly important to muskrats for foraging.

Rationale: This habitat is important for foraging. Vegetation density should be maintained above ≤50 % cover to provide areas for foraging.

Deep marsh

This type should cover between 5–10% of Orange Lake and Lochloosa Lake, and up to 5% of Newnans Lake. This habitat is directly important to round-tailed muskrats for foraging, including associated adjacent habitats.

Table A 4. Non-inclusive list of mammal species that are expected to occur within the region of the Orange Creek Basin (OCB).

Order	Common name	Scientific name	Presence[1]
Marsupials			
	Opossum	*Didelphis virginiana*	Transient
Insectivores			
	Southeastern shrew	*Sorex longirostris*	Transient
	Southern short-tailed shrew	*Blarina carolinensis*	Transient
	Least shrew	*Cryptotis parva*	Transient
Bats			
	Southeastern bat	*Myotis austroriparius*	Transient
	Eastern pipistrelle	*Pipistrellus subflavus*	Transient
	Big brown bat	*Eptesicus fuscus*	Transient
	Red bat	*Lasiurus borealis*	Migratory
	Northern yellow bat	*Lasiurus intermedius*	Transient
	Seminole bat	*Lasiurus seminolus*	Resident
	Evening bat	*Nycticeus humeralis*	Resident
	Rafinesque's big-eared bat	*Corynorhinus rafinesquii*	Resident
Armadillos			
	Nine-banded armadillo	*Dasypus novemcinctus*	Transient
Rabbits			
	Marsh rabbit	*Sylvilagus palustris*	Resident
Rodents			
	Round-tailed muskrat	*Neofiber alleni*	Resident
	Cotton rat	*Sigmodon hispidus*	Resident
	Marsh rice rat	*Oryzomys palustris*	Resident
Carnivores			
	Otter	*Lutra canadensis*	Resident
	Raccoon	*Procyon lotor*	Transient
	Long-tailed weasel	*Mustela frenata*	Transient
	Gray fox	*Urocyon cinereoargenteus*	Transient
	Coyote	*Canis latrans*	Transient
	Bobcat	*Lynx rufus*	Transient
Ungulates			
	Hog	*Sus scrofa*	Resident

[1] Resident = spends the majority of its lifecycle in habitats of the OCB. Transient = moves through and spends some time in habitats of the OCB throughout the year, but also uses other habitats extensively. Migratory = only expected to occur in habitats of the OCB during specific seasons.

Table A 5. Mammal focal taxa goals for Orange Lake.

Habitat type	Total target area of habitat type (percent of lake)	Degree of interspersion	Block size	Percent vegetation coverage	Density	Location
Shallow marsh	High 20-30%	High		Moderate and varied	Dense (high)	Across area
Deep marsh	Low 5-10%	Moderate	Generally small	Moderate 20-40%	Dense (high)	Across entire area
Floating island	Low 1-5%	Moderate	Moderate - Large	Moderate30-40%	Dense	Across area
Floating marsh	Moderate 15-20%	High	Moderate	High 80-100%	Dense (high)	Across area
Shrub swamp	High 1-5%	High		High 70-90%	Dense (high)	Across area
Tree island	Low 0.5-5%	N/A	N/A	N/A	N/A	N/A
Open water	High 40-60%	High		N/A	Sparse (low)	Across area
SAV	N/A	N/A	N/A	N/A	N/A	N/A

Table A 5. Continued.

Habitat type	Preferred vegetation species (in order of importance)	Preferred substrate	Focal taxa strategies
Shallow marsh	Maidencane, pickerelweed, arrowheads, knotweed, spatterdock, and/or arrow arum (*Peltandra virginicum*)	N/A	Burn on regular basis 3-5 years, Create areas by manipulating water level, Control water level to inundate areas, Maintain full range of natural water level fluctuations and natural intervals (5, 10, and 25-year cycles), Restore natural fire frequency, intensity, and seasonality to the extent possible (3–5-year burn cycle), Allow severe fire (peat fire) every 15–20 years, and Spot treatment of woody vegetation as needed to maintain shallow marsh habitat
Deep marsh	Maidencane, pickerelweed, knotweed, spatterdock, and/or srrow arum	N/A	The overall strategy would be to maintain an early successional community, Maintain full range of natural water level fluctuations and natural intervals (5, 10, and 25-year cycles), Restore natural fire frequency, intensity, and seasonality to the extent possible (3–5-year burn cycle), Allow severe fire (peat fire) every 15–20 years, and Spot treatment of woody vegetation as needed to maintain deep marsh habitat
Floating island	Maidencane, arrowheads, knotweed, and/or arrow arum	N/A	The overall strategy would be to maintain an early successional community, Maintain full range of natural water level fluctuations and natural intervals (5, 10, and 25-year cycles), Restore natural fire frequency, intensity, and seasonality to the extent possible (3–5-year burn cycle), Allow severe fire (peat fire) every 15–20 years, and Spot treatment of woody vegetation as needed to maintain marsh habitat
Floating marsh	Arrowheads, knotweed, arrow arum, pickerelweed, and/or water pennywort	N/A	The overall strategy would be to maintain an early successional community, Maintain full range of natural water level fluctuations and natural intervals (5, 10, and 25-year cycles), and Spot treatment of woody vegetation as needed to maintain marsh habitat
Shrub swamp	Arrowheads and arrow arum	N/A	Burn on regular basis 3-5 years, Create areas by manipulating water level, Manage as a forage area, Control water level to inundate areas
Tree island	Arrowheads and arrow arum	N/A	Muskrats will use habitat edge for feeding & gathering nest materials
Open water	N/A	N/A	Manage large open water areas for movement and foraging, and Control water level to inundate areas or open them for burning.
SAV	N/A	N/A	N/A

Table A 6. Mammal focal taxa goals for total target area of habitat type (percent of lake) on Lochloosa Lake and Newnans Lake.

Habitat type	Lochloosa Lake	Newnans Lake
Shallow marsh	20–30%	10–15%
Deep marsh	5–10%	<5%
Floating island	1-5%	<1%
Floating marsh	10–15%	10–15%
Shrub swamp	5–10%	<5%
Tree island	<1%	<1%
Open water	40-60%	N/A
SAV	N/A	N/A

Rationale: This habitat is important for round-tailed muskrats. Core of this habitat type not important for muskrats. Vegetation density along edge should be composed of emergent plants with less than or equal to 50% cover.

Floating marsh

This type should cover between 15–20% of Orange Lake, and 10-15% of Lochloosa Lake and Newnans Lake. This habitat is directly important to muskrats with habitat edge being utilized for foraging.

Rationale: This habitat is important for foraging. Vegetation density along edge should be composed of emergent plants with 80–100% cover.

Floating islands

This type should cover between 1–5% of Orange Lake and Lochloosa Lake, and <1% of Newnans Lake. This habitat is directly important to muskrats with habitat edge being utilized for foraging.

Rationale: This habitat is important for foraging. Vegetation density along edge should be composed of emergent plants with 60–80% cover.

Shrub swamp

This type should cover between 1–5% of Orange Lake, 5-10% of Lochloosa Lake, and <5% of Newnans Lake. This habitat is directly important to muskrats with habitat edge being utilized for foraging

Rationale: This habitat is important for foraging and loafing. Vegetation density should be maintained near ≤50% cover to provide areas for foraging.

Tree islands

This habitat type should be <5% of Orange Lake and <1% of Lochloosa Lake and Newnans Lake. This habitat is not directly important to muskrats although edge will be used.

Rationale: This habitat is not directly important to muskrats.

Open water

This type should cover between 40–60% of the lakes. This habitat is directly important to muskrats for movement with habitat edge being utilized for foraging.

Rationale: This habitat is important for movement and foraging. Vegetation density should be minimized to provide open areas for movement and foraging.

Literature cited

Birkenholz, D.E. 1963. A study of the life history and ecology of the round-tailed muskrat (*Neofiber alleni* True) in north-central Florida. Ecological Monographs 33(3):255-280.

Birkenholz, D.E. 1972. Species account: *Neofiber alleni*. Mammalian species 15:1-4.

Hafner, D.J., E. Yensen and G.L. Kirkland. 1998. I*n*: Hafner, D.J., E. Yensen and G.L. Kirkland, eds. North American Rodents: Status Survey and Conservation Action Plan. Island Press, Washington D.C., USA.

University of Georgia. 2007. Species description: Round-tailed muskrat (*Neofiber alleni*), online. Accessed October 12, 2007. http://fishesofgeorgia.uga.edu/gawildlife/index.php?page=speciespages/species_page&key=nalleni

WADING BIRDS

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Summary

Many species of wading birds occur in the OCB. Wading birds are defined here as a focal taxon that includes but is not limited to herons, bitterns, ibis, storks, rails, coots, common moorhens, and sandhill cranes (Table A 7). These species foraging on plants, animals, and invertebrates throughout the marshes of the OCB. Adults and nests are subject to predation by predatory birds (i.e., owls and hawks), mammals (i.e., bobcats and raccoons), and reptiles (i.e., alligators). Along with foraging, these species use different areas in the OCB to roost and nest. For the goals outlined herein, focal species include federally listed wood stork (*Mycteria americana*); state listed sandhill cranes (*Grus canadensis pratensis*), little blue heron (*Egretta caerulea*), tricolored herons (*E. tricolor*), and roseate spoonbill (*Platalea ajaja*); and species of special concern including snowy egret (*E. thula*) and white ibis (*Eudocimus albus*). These imperiled species will be targeted when identifying specific objectives for management activities occurring in the OCB and will follow any recommendations in the appropriate Species Action Plans (Boughton et. al. 2013, Dwyer et. al. 2013).

Herein we identify the objectives for maintaining desirable foraging and nesting habitat for wading birds on Orange Lake within eight generalized habitat types (Table A 8). For species in Ciconiiformes (herons, egrets, bitterns, ibis and storks), there is an assumption that nesting success depends on quality and quantity of nesting and foraging habitat. Good quality foraging habitat should improve foraging success rates, which ultimately would result in higher nestling survivorship and fledging rates when coupled with available nesting substrate. Good quality nesting substrate provides a stable nesting platform, which should lessen the probability of nest collapse and whole nest failure. Without suitable foraging habitat, wading birds cannot access the food resources of a wetland and provide nourishment for their nestlings.

Evidence suggests that nesting habitat is not a limiting factor for wading birds (Rodgers et al. 1996). Rather, prey availability or accessibility to these food resources is the limiting factor on reproductive success and population growth of wading birds. However, having available nesting habitat in proximity to good foraging habitat may provide the stimulus for breeding. Lastly, the dynamic nature of the littoral zone and prey availability on Orange Lake may require wading birds to use off-lake foraging sites, especially ephemerally rich food resources. Thus, these species may not be entirely dependent upon a single foraging area such as Orange Lake. Other species, particularly rails and gallinules are solely dependent on the food resources on the lake.

Background

Wading birds as a generic term includes a diverse group of birds utilizing aquatic habitats and adjacent forested wetland habitats. Most wading birds are in the avian order Ciconiiformes and families Ardeidae (herons, egrets, and their allies), Threskiornithidae (ibises and spoonbills), and Ciconiidae (storks). Some biologists also include members of the families Pelecanidae (pelicans), Phalacrocoracidae (cormorants), Anhingidae (anhingas), Scolopacidae (shorebirds), Gruidae (cranes), Rallidae (rails and gallinules), and Aramidae (limpkins). For purposes of this report, only the species of Ciconiiformes will be considered for management activities.

Table A 7. Non-inclusive list of shorebird and wading bird species that have been observed within the Orange Creek Basin.

Category	Common Name	*Scientific Name*	Presence
SHOREBIRDS			
	Black-necked stilt	*Himantopus mexicanus*	Migrant
	Dunlin	*Calidris alpina*	Migrant
	Greater yellowlegs	*Tringa melanoleuca*	Migrant
	Least sandpiper	*Calidris minulilla*	Migrant
	Lesser yellowlegs	*Tringa flavipes*	Migrant
	Stilt sandpiper	*Calidris himantopus*	Migrant
	Long-billed dowitcher	*Limnodromus scolopaceus*	Resident
WADING BIRDS - LONG LEGS			
	Black-crowned night heron	*Nycticorax nycticorax*	Resident
	Cattle egret	*Bubulcus ibis*	Resident
	Glossy ibis	*Plegadis falcinellus*	Resident
	Great blue heron	*Ardea herodias*	Resident
	Great egret	*Casmerodius albus*	Resident
	Limpkin	*Aramus guarauna*	Resident
	Little blue heron	*Egretta caerulea*	Resident
	Sandhill crane	*Grus canadensis*	Resident
	Snowy egret	*Egretta thula*	Resident
	Tricolored heron	*Egretta tricolor*	Resident
	White ibis	*Eudocimus albus*	Resident
	Wood stork	*Mycteria Americana*	Resident
WADING BIRDS - SHORT LEGS			
	Common gallinule	*Gallinula galeata*	Resident
	Green heron	*Butorides striatus*	Resident
	King rail	*Rallus elagans*	Resident
	Least bittern	*Ixobrychus exilis*	Resident
	Purple gallinule	*Porphyrio martinicus*	Resident
	Sora rail	*Porzana Carolina*	Migrant

Table A 8. Wading birds focal taxa goals for Orange Lake.

Habitat type	Total target area of habitat type (percent of lake)	Degree of interspersion	Block size	Percent vegetation coverage	Density	Location
Shallow marsh	High 30-40%	High	Moderate, variable	Moderate and varied 50%	High to moderate (patchy distribution of emergent plants with ≤50% cover per hectare)	Across area, priority to areas near known roots or potential nest sites (i.e., continually flooded willow stands)
Deep marsh	Low 1-5%	Moderate	Generally small	High 40-60%	Moderate (patchy distribution of emergent plants with ≤50% cover per hectare)	Across entire area
Floating island	Low 1-5%	High	Block size should be balanced to provide interior and edge habitat.	Medium 50%	Moderate	Across area
Floating marsh	Low: 15-20%	High	Moderate (hundreds of square meters in size)	Medium 50%	Moderate (patchy distribution of emergent plants with ≤50% cover per hectare)	Across area
Shrub swamp	Low: 5-10%	High	Varied, mostly a few acres	High 70-90%	Moderate (patchy distribution of emergent plants with ≤50% cover per hectare)	Across area, PG Run. Priority to dense areas near good forage that are frequently flooded.
Tree island	Low: <1%	High	Large but varied	High 50-80%	Moderate-High	Across area, priority to sites <100 m from good foraging to increase success of newly fledged juvenile birds.
Open water	Moderate: 40-50%	High	Small (few acres each)	N/A	Very low	Across area
SAV	N/A	N/A	N/A	N/A	N/A	N/A

Table A 8. Continued.

Habitat type	Preferred vegetation species (in order of importance)	Preferred substrate	Focal taxa strategies
Shallow marsh	Can use sub-habitat types: All	Vegetation itself, mud, exposed muck, sand.	The overall strategy would be to maintain structure in this habitat type, Restore natural fire frequency, intensity, and seasonality to the extent possible (3–5-year burn cycle; peat fire every 15–20 years), Create structure by encouraging diverse plant species. Create areas by manipulating water level. (i.e., littoral zones that concentrate prey), and Spot treatment of woody vegetation as needed to maintain shallow marsh habitat
Deep marsh	Can use sub-habitat types: All	N/A	The overall strategy would be to maintain an early successional community, Maintain full range of natural water level fluctuations and natural intervals (5, 10, and 25-year cycles), Restore natural fire frequency, intensity, and seasonality to the extent possible (3–5-year burn cycle), and Spot treatment of woody vegetation as needed to maintain deep marsh habitat
Floating island	N/A	N/A	The overall strategy would be to maintain 3-dimensional structure in this habitat type, Restore natural fire frequency, intensity, and seasonality to the extent possible (3–5-year burn cycle), and Create structure on floating islands with downed trees and woody debris
Floating marsh	Can use sub-habitat types: low floating marsh; water pennywort, knotweed, and red temple (*Alternanthera reineckii*)	N/A	Important as habitat for nesting and roosting, Develop as forage component for some wading birds, and Restore natural fire frequency, intensity, and seasonality to the extent possible (3–5-year burn cycle)
Shrub swamp	Willow and buttonbush, Can use sub-habitat types: All	Vegetation itself, mud, exposed muck, sand	The overall strategy would be to maintain 3-dimensional structure in this habitat type, especially of woody plants to encourage nesting by solitary wading birds, Restore natural fire frequency, intensity, and seasonality to the extent possible (3–5-year burn cycle), Create structure by encouraging diverse plant species, and Create areas by manipulating water level. (Littoral zone)
Tree island	Red maple and bald cypress	Vegetation itself, edge for forage.	The overall strategy would be to maintain structure in this habitat type to encourage nesting of both solitary and colonial species, Disturbance should be reduced or eliminated during nesting season (No public access during this time), Restore natural fire frequency, intensity, and seasonality to the extent possible (3–5-year burn cycle), Maintain at successional end-point, Maximize 3 dimensional structure of these islands, and Control access by non-native predators (cats, dogs) and remove if present
Open water	Can use sub-habitat types: Limited by depth	Mud, exposed muck, sand	Manage shallow areas as emergent free areas when shorebirds present. (Littoral zone)
SAV	N/A	N/A	N/A

However, the upland foraging requirements of the cattle egret (*Bubulcus ibis*) will not be discussed.

All species of wading birds in Florida also occur elsewhere in the temperate regions of United States and throughout tropical regions of Central and South America (Palmer 1962, Hancock and Kushlan 1984). However, Florida historically possessed the largest number of species and populations of Ciconiiformes wading birds in the United States (Runde 1991). Precipitous decreases in the populations of wading birds in Florida during the mid-1900s, especially in south Florida, ultimately resulted in many species being listed as endangered (wood stork), state imperiled [little blue heron, tricolored herons, reddish egret (*Egretta rufescens*), roseate spoonbill] or species of special concern (snowy egret, white ibis). Florida's resident population of wading birds is augmented by migratory birds from more northern latitudes (especially the Atlantic coastal populations) during the months of October-March (Palmer 1962, Hancock and Kushlan 1984). Central Florida lakes and wetlands, including water bodies in the OCB, are important to both resident nesting and foraging wading birds and migrant wading birds that disperse into the state during the winter. Significant degradation of these wetlands would result in decreased numbers of wading birds using the OCB and adjacent lakes in central Florida.

Focal taxa goals

Maintain or enhance large patches of desirable shallow marsh habitat (for foraging), floating marsh and shrub swamp habitat (loafing and nesting) and tree island habitat (for nesting and loafing), to maintain large, robust wading bird populations on each of the water bodies of the OCB where such habitat has been known to occur. In water bodies where large patches of shallow marsh, floating marsh, shrub swamp, and tree island habitats do not occur, maintain small patches of these habitats, where possible given the historical conditions in those water bodies, to enhance the stability and long-term viability of the wading bird populations within the OCB. Manage wetland habitats to maintain availability and accessibility to foraging areas and/or food resources, available nesting habitat in proximity to good foraging habitat, and available off-lake foraging sites (especially ephemerally rich food resources. Maintain sufficient area and distribution of shallow marsh, floating marsh, shrub swamp, and tree island habitat within water bodies and across the OCB to accommodate expected natural fluctuations in habitat availability and quality caused by fluctuation in water levels.

Objectives – based on habitat types

Shallow marsh

Under typical conditions (i.e., constant water levels), shallow marsh areas targeted for wading birds can make up 30–40% of Orange Lake (Table A 8) and Lochloosa Lake (Table A 9) and up to 15% of Newnans Lake (Table A 9). . Habitat and habitat edge not deeper than 1 ft (0.3 m) will be utilized by wading birds. Vegetation density should be maintained near ≤50% cover to provide areas for foraging.

Rationale: Shallow marsh habitat, dominated by moderately dense to dense emergent vegetation, is high quality habitat for wading birds. This habitat is important to wading birds both for foraging and loafing. It should be a top priority for management activities to maintain or

Table A 9. Wading bird focal taxa goals for total target area of habitat type (percent of lake) on Lochloosa Lake and Newnans Lake.

Habitat type	Lochloosa Lake	Newnans Lake
Shallow marsh	30–40%	10–15%
Deep marsh	<5%	<5%
Floating island	1-5%	<1%
Floating marsh	5–10%	5–10%
Shrub swamp	5–10%	5–10%
Tree island	<1%	<1%
Open water	40–50%	N/A
SAV	N/A	N/A

increase the coverage (abundance) of this habitat in the water bodies of the OCB where large patches of this habitat occur or have been known to occur historically, such as Orange Lake, Lochloosa Lake, and Paynes Prairie. Small patches of shallow marsh habitat should be managed for wading birds on Newnans Lake but historically, little of this habitat has persisted on the lake.

Deep marsh

This type should cover between 1–5% of the lakes in the OCB. This habitat is not directly important to wading birds, however edge associated with adjacent habitats will be utilized by wading birds for foraging.

Rationale: This habitat is important for species such as gallinules and coots. This habitat type not important for other wading birds. Vegetation density along edge should be composed of emergent plants with less than 50% cover.

Floating islands

This type should cover between 1–5% of the lakes in the OCB. This habitat is directly important to wading birds with habitat edge being utilized by wading birds for foraging.

Rationale: This habitat is important for nesting species. Edge not deeper than 1 ft (0.3 m) of this type will be utilized by wading birds. Vegetation density along edge should be composed of emergent plants with 50% cover.

Floating marsh

Under typical conditions, floating marsh areas targeted for wading birds should make up 15–20% of Orange Lake, and up to 10% of Lochloosa Lake and Newnans Lake (Tables A 8 and A 9).

Rationale: Low floating marsh habitat, dominated by moderately dense to dense emergent vegetation including water pennywort, knotweed, and red temple (*Alternanthera reineckii*), is high quality habitat for wading birds. This habitat is important to wading birds for nesting, roosting, and foraging. It should be a top priority for management activities to maintain or increase the coverage (abundance) of this habitat in the water bodies of the OCB where moderate sized (hundreds of square meters) patches of this habitat occur or have been known to occur historically such as Orange Lake and Paynes Prairie. Smaller patches of floating marsh habitat

should be managed for wading birds on Lochloosa Lake and Newnans Lake. Vegetation density along edge should be composed of emergent plants with 50 % cover.

Shrub swamp

Under typical conditions, shrub swamp areas targeted for wading birds can make up 5–10% Orange, Lochloosa and Newnans Lakes (Table A 8 and A 9).

Rationale: Shrub swamp habitat, dominated by moderately dense to dense woody substrate is high quality habitat for wading birds. This habitat is important to wading birds for loafing and nesting, and when comprised of woody species including willow and buttonbush, can be used for nesting by the smaller solitary wading bird species (i.e., green heron and least bittern). It should be a top priority for management activities to maintain the coverage (abundance) of this habitat in the water bodies of the OCB where moderate sized (few acres) patches of this habitat occur or have been known to occur historically, such as Orange Lake, Lochloosa Lake, and Paynes Prairie. Smaller patches of shrub swamp habitat should be managed for wading birds on Newnans Lake but historically, little of this habitat has persisted on the lake.

Tree islands

Under typical conditions, tree island areas targeted for wading birds should make up <1% of Orange Lake, Lochloosa Lake and Newnans Lake (Tables A 8 and A 9).

Rationale: Tree island habitat, dominated by moderately dense to dense woody substrate including red maple and bald cypress is high quality habitat for wading birds. This habitat is important for nesting (solitary and colonial species) and loafing where they are flooded or free of terrestrial predators (especially for wood storks) and when they are located in close proximity to active wading bird rookeries. It should be a top priority for management to maintain or increase the coverage (abundance) of this habitat in the water bodies of the OCB where moderate sized (few acres) patches of this habitat occur or have been known to occur historically such as Orange Lake, Lochloosa Lake, and Paynes Prairie. Smaller patches of tree island habitat should be managed for wading birds on Newnans Lake but historically, little of this habitat has persisted on the lake.This habitat type should be <1% of the lake. This habitat is directly important to wading birds with habitat interior being utilized by wading birds for nesting and loafing.

Rationale: This habitat is important for nesting and loafing where they are flooded or free of terrestrial predators-especially for wood storks. Vegetation density should be maintained above >50% cover to provide areas for nesting and predator avoidance.

Open water

This type should cover between 40–50% of the lake. This habitat is directly important to wading birds with habitat edge being utilized by wading birds for foraging.

Rationale: This habitat edge is important for foraging and loafing. Habitat and habitat edge not deeper than 1 ft (0.3 m) will be utilized by wading birds. Vegetation density should be minimized to provide open areas for foraging. In addition, high water on the lake, which tends to be synonymous with lots of open water, often corresponds with adequate water under nesting colonies needed for predator protection.

Literature cited

Boughton, R., K. Rezac, J. Rodgers, E. Sachs, T. Towles, and Z. Welch. 2013. A species action plan for six imperiled wading birds: Little blue heron (*Egretta caerulea*), reddish egret (*Egretta rufescens*), roseate spoonbill (*Platalea ajaja*), snowy egret (*Egretta thula*), tricolored heron (*Egretta tricolor*), and white ibis (*Eudocimus albus*). Florida Fish and Wildlife Conservation Commission, Tallahassee, Florida.

Dwyer, N., A. Clifton, M. Folk, and B. Stys. 2013. A species action plan for the Florida Sandhill Crane Grus *Canadensis pratensis*. Florida Fish and Wildlife Conservation Commission, Tallahassee, Florida.

Hancock, J. and J. A. Kushlan. 1984. The herons of the world. Harper and Row, New York, New York.

Palmer, R. S. 1962. Handbook of North American birds. Volume 1. Yale University Press, New Haven, Connecticut.

Rodgers, J. A., Jr., S. T. Schwikert, and A. Shapiro-Wenner. 1996. Nesting habitat of wood storks in north and central Florida, USA. Colonial Waterbirds 19:1-21.

Runde, D. E. 1991. Trends in wading bird nesting populations in Florida: 1976-1978 and 1986-1989. Final performance report, Florida Game and Freshwater Fish Commission, Tallahassee, Florida.

WATERFOWL

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Background

The Orange Creek Basin Working Group (OCBWG) is tasked with managing the fish and wildlife resources within the OCB. This section specifies quantitative objectives to guide management for the benefit of waterfowl.

Anticipated benefits of achieving the objectives will be (1) increased average populations of wood ducks (*Aix sponsa*; year-round) and wintering waterfowl (November – February), (2) increased waterfowl hunting activity, (3) increased waterfowl harvest, (4) higher satisfaction of waterfowl hunters who hunt on Orange Lake, and (5) increased recreational use by people interested in viewing wildlife.

The overriding assumption is that vegetative structure is the current limiting factor. It is possible that other factors, both within and outside of the OCB lakes, limit waterfowl use. Possibilities include altered hydrology, insufficient invertebrate foods, changing wintering distribution of waterfowl within and outside of Florida, reduced regional/statewide/continental waterfowl populations, and habitat conditions elsewhere in central Florida. There are essentially no quantitative scientific findings on which to base specific, quantifiable objectives regarding vegetative structure and composition for waterfowl habitat. The objectives herein were determined by the best professional judgment of FWC waterfowl staff.

Historically, the most abundant species on OCB lakes were ring-necked ducks (*Aythya collaris*), ruddy ducks (*Oxyura jamaicensis*), green-winged teal (*Anas crecca*), lesser scaup (*Aythya affinis*), American widgeon (*Anas americana*), mallards (*Anas platyrhynchos*), and blue-winged teal (*Anas discors*; Figure A 1). Recent survey data indicate that ring-necked ducks, ruddy ducks, lesser scaup, blue-winged teal, and green-winged teal are now the primary species. Wood ducks are locally abundant on Orange Lake but are rarely counted from fixed-wing surveys, as they are inherently difficult to spot in hardwood and shrub swamp. The OCB lakes provide habitat for both a resident and migratory population of wood ducks. The two waterfowl species selected to represent the waterfowl focal taxon for management of the OCB lakes are the wood duck and ring-necked duck. The wood duck was chosen because it is commonly found on the lake, and many of its habitat requirements overlap with other dabbling duck species that migrate through and winter on the lakes each year. Wood ducks are opportunistic omnivores that can utilize many different types of habitat. Therefore, by providing quality habitat for the non-migratory wood duck throughout its annual cycle, the habitat requirements for other dabbling duck species during migration and winter also would largely be met. The ring-necked duck was chosen as an indicator to represent the group of ducks known as diving ducks. Florida supports a large proportion (upwards of 22%; Bellrose 1980) of the North American ring-necked duck population during winter. Thus, having adequate wintering habitat for this species in the state is important to the continental population. The ring-necked duck usually is the most numerous species in Florida's waterfowl sport harvest (U. S. Fish and Wildlife Service harvest data) and the most abundant and widespread diving duck species using freshwater wetlands in the state (Eggeman et al. 1997, FWC file data).

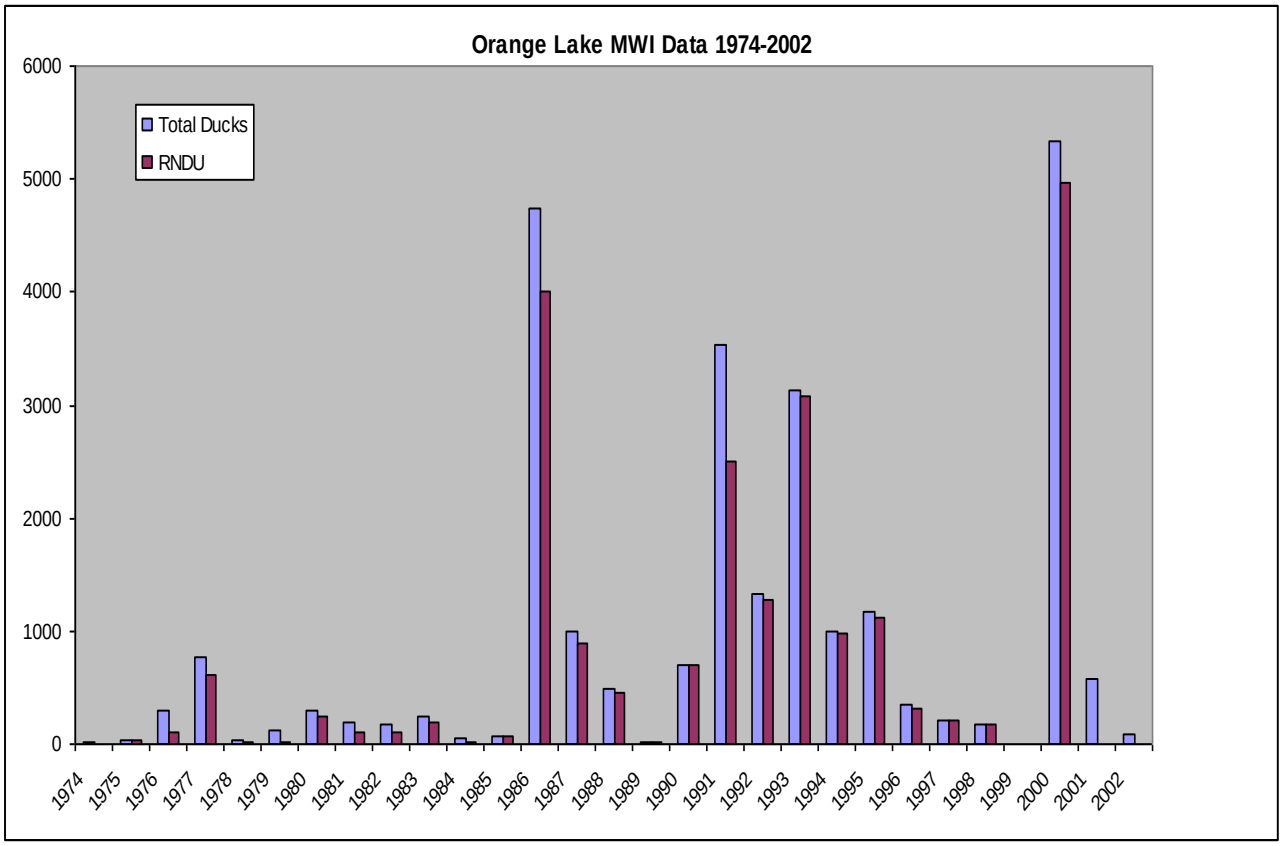

Figure A 1. U.S. Fish and Wildlife Service mid-winter waterfowl inventory on Orange Lake. Ring-necked ducks (RNDU) account for the majority of wintering ducks on Orange Lake.

Focal taxa goals

Provide waterfowl habitat capable of sustaining an abundance of migratory and resident ducks in the OCB.

Objectives – based on habitat types

Shallow marsh

Manage this habitat for a mosaic of 30-60% vegetative cover and moderate interspersion to provide use by wood ducks and dabbling ducks on Orange Lake (Table A 10). Shallow marsh should make up 20-30% of Orange Lake (Table A 10) and Lochloosa Lake (Table A 11), and 5-20% of Newnans Lake (Table A 11).

Rationale: Wood ducks regularly use shallow, emergent portions of lakes in central Florida, because these areas typically provide a combination of food and cover. Dabbling ducks feed primarily by tipping at the surface; therefore, they require relatively shallow water (7-16 inches, 18-40 cm) to forage effectively (Hepp and Bellrose 1995). A 50:50 mix of water to emergent plants is considered optimal for marsh birds (Weller and Spatcher 1965, Figure A2).

Table A 10. Waterfowl focal taxa goals for Orange Lake.

Habitat type	Total target area of habitat type (percent of lake)	Degree of interspersion	Block size	Percent vegetation coverage	Density	Location
Shallow marsh	20-30%	Emergent vegetation should form a mosaic of patches varying in size and shape, with an average contagion index of 30	N/A	30-60%	N/A	N/A
Deep marsh	10-30%	Spatterdock and other water lilies should range from a mosaic of patches varying in size and shape to a solid stand. Topped out hydrilla would increase attractiveness to waterfowl	N/A	50-100% water lilies, 20-100% SAV	Moderate to High	N/A
Floating island						
Floating marsh						
Shrub swamp	5-10%	Vegetation should range between a mosaic of patches varying in size and shape and a solid stand of shrub swamp	0.1 ha (0.25 acres) acre or larger	Greater than 50%	High	N/A
Tree island						
Open water						
SAV						
Hydrilla	>10%, all topped-out or within 6 inches of surface from Nov-Feb	N/A	5 ha (12.4 acres) or larger	N/A	N/A	Hydrilla may exist in shallow marsh, deep marsh, or areas void of emergent vegetation (open water)

Table A 10. Continued.

Habitat type	Preferred vegetation species (in order of importance)	Preferred substrate	Focal taxa strategies
Shallow marsh	Rushes (*Juncus* spp.), cord grass (*Spartina* spp.), southern cutgrass, arrowhead, broom grass (*Andropogon* spp.), maidencane, pickerelweed, arrow arum, cattail (*Typha latifolia*), sawgrass, bulrush (*Schoenoplectus* spp.), southern wild rice (*Zizaniopsis miliacea*), and water shield	N/A	Maintain full range of natural water level fluctuations, Restore natural fire frequency, intensity, and seasonality, and Chemical/mechanical manipulation to maintain target interspersion and percent vegetation coverage levels
Deep marsh	Water lily, spatterdock, American lotus, water shield, and hydrilla	N/A	Maintain full range of normal water level fluctuations, mechanical-cut trails for access, and If present, maintain topped out hydrilla from November-February annually
Floating island			
Floating marsh			
Shrub swamp	Wax myrtle, elderberry (*Sambucus canadensis*), buttonbush, and willow	N/A	Maintain full range of natural water level fluctuations, Restore natural fire frequency, intensity, and seasonality, and Allow severe burns every 15-20 years
Tree island			
Open water			
SAV			
Hydrilla		N/A	Mechanical harvesting and/or herbicide treatment of hydrilla to maintain open trails from November – February annually

Table A 11. Waterfowl focal taxa goals for total target area of habitat type (percent of lake) on Lochloosa Lake and Newnans Lake.

Habitat type	Lochloosa Lake	Newnans Lake
Shallow marsh	20–30%	5-20%
Deep marsh	5–20%	5-20%
Floating island	0–5%	0–5%
Floating marsh	0–5%	0–5%
Shrub swamp	1-5%	1–10%
Tree island	N/A	N/A
Open water	N/A	N/A
SAV	0-25%	0-10%

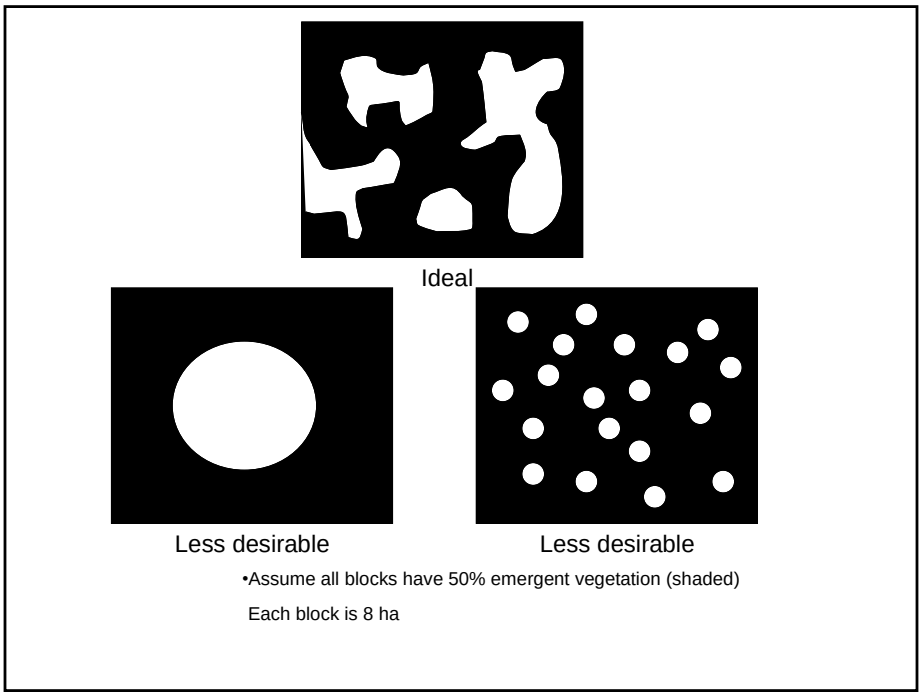

Figure A 2. Graphic representation of ideal waterfowl habitat.

Deep marsh

Indefinitely manage deep marsh areas to provide 50-100% coverage of water lilies (*Nymphaea* spp.) in moderate density with 20-100% submersed vegetation. Deep marsh should make up 10-30% of Orange Lake, and 5-20% of Lochloosa and Newnans Lakes.

Rationale: Ring-necked ducks require habitats that provide adequate food and protective cover. Traditionally in Florida, ring-necked ducks used deep-marsh habitats characterized by floating-leaved and aquatic-bed type wetland vegetation. Seeds of fragrant water lily (*Nymphaea odorata*), spatterdock, American lotus, and water shield (*Brasenia schreberi*) are considered preferred foods. These plants can also provide protective cover. The presence of submersed vegetation increases the value of this habitat type by providing additional animal and plant foods.

Shrub swamp

Manage this habitat in moderate to dense blocks of 50-100% vegetative cover to promote use by wood ducks. Shrub swamp should make up 5-10% of Orange Lake, 1-5% of Lochloosa Lake and 1-10% of Newnans Lake.

Rationale: Habitat composed of buttonbush and other shrubs provide overhead cover and are used extensively by wood ducks (Hepp and Hair 1977). Ideally, scrub/shrub habitat should provide dense cover approximately 2 feet (0.6 m) above the water surface (McGilvrey 1968) and have open water, sparse vegetation or submersed vegetation beneath.

Floating islands and floating marsh

If present, floating islands and floating marshes should be limited to small patches, creating edge and heterogeneity among and between shallow and deep marsh habitats. Floating islands and floating marsh should make up 0-5% of Orange, Lochloosa and Newnans Lakes.Rationale: Floating islands and floating marsh with low floating plants such as frog's bit provide edge in shallow and deep marsh systems. Such areas are used for cover and loafing sites by juvenile and molting adult ducks during summer.

Hydrilla

When present, allow areas of topped-out hydrilla to remain in open water, shallow and deep marsh, or shrub swamp to provide food for waterfowl during fall and winter. Hydrilla may be present up to 10% on Orange and Newnans Lakes and up to 25% on Lochloosa Lake.

Rationale: Based on aerial surveys and other field observations in recent years of wintering waterfowl in central and southern Florida, the distribution of ring-necked ducks appears to be determined primarily by the presence and abundance of topped-out hydrilla beds. Johnson and Montalbano (1984) studied the selection of plant communities by wintering waterfowl in the littoral zone of Lake Okeechobee. In this study, ring-necked ducks were the most abundant species observed. Of all vegetative communities available, hydrilla received the highest preference ranking. Hydrilla is a predominant duck food in areas where it occurs (Montalbano et al. 1978, 1979). Ring-necked ducks feed on all parts of hydrilla, including vegetation, tubers, and turions. Other food plants valuable to this species include marine naiad (*Najas marina*), pondweeds (*Potamogeton* sp.), and wild celery (*Apium graveolens*; Montalbano et al. 1978, Johnson and Montalbano 1984). Such areas may exist in shallow and deep marsh habitat, or areas void of emergent vegetation (i.e., open water).

Literature cited

Bellrose, F. C. 1980. Ducks, geese and swans of North America. Stackpole Books, Harrisburg, Pennsylvania, USA.

Hepp, G. R., and F. C. Bellrose. 1995. Wood Duck (*Aix sponsa*). *In* The Birds of North America, No. 169 (A. Poole and F. Gill, eds.). The Academy of Natural Sciences, Philadelphia, and The American Ornithologists' Union, Washington, D.C.

Hepp, G. R. and J. D. Hair. 1977. Wood Duck brood mobility and utilization of beaver pond habitats. Proc. Annu. Conf. Southeast. Assoc. Fish Wildl. Agencies 31: 216-225.

Eggeman, D. R., F. A. Johnson, M. J. Conroy, and D. H. Brakhage. 1997. Evaluation of an Aerial Quadrat Survey for Monitoring Wintering Duck Populations. Journal of Wildlife Management 61(2):403-412.

Johnson, F. A. and F. Montalbano, III. 1984. Selection of plant communities by wintering waterfowl on Lake Okeechobee, Florida. Journal of Wildlife Management 48:174-178.

McGilvrey, F. B. 1968. A guide to wood duck production habitat requirements. Res. Publ. 60. U. S. Fish Wildl. Serv. 32 pp.

Montalbano, F., III, S. Hardin, and W. M. Hetrick. 1979. Utilization of hydrilla by ducks and coots in central Florida. Proceedings Annual Conference Southeastern Association Game and Fish Commissioners 33:36-42.

Montalbano, F. III., W. M. Hetrick, and T. C. Hines. 1978. Duck foods in central Florida phosphate settling ponds. Pages 247-255 *in* D. E. Samuel, J. R. Stauffer, C. H. Hocutt, and W. T. Mason, editors. Surface mining and fish/wildlife needs in the eastern U.S. U.S. Fish and Wildlife Service, FWS/OBS-78/81.

Weller, M. W. and C. E. Spatcher. 1965. Role of habitat in the distribution and abundance of marsh birds. Iowa State University Agriculture and Home Economics Experiment Station, Special Report 43, Ames, Iowa, USA.

FISH

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Background

Orange Lake has a history of being a popular destination for recreational and professional anglers. On average, anglers spent 78,000 hours on fishing during spring-month surveys from 1971 to present, with a range of 26,000 angler hours (1991) to 176,000 angler hours (1988; FWC, unpublished data). The fish species most sought by anglers varies from year to year, but typically anglers targeting largemouth bass (*Micropterus salmoides*) account for the highest angling effort, followed by panfish (*Lepomis* sp.), then black crappie (*Pomoxis nigromaculatus*). Due to the success of anglers targeting these fisheries, Orange Lake is frequently recognized on the Fish and Wildlife Conservation Commission (FWC) list of top Florida fishing lakes. Consequently, the Orange Lake fisheries contribute heavily to the local economy. In particular, the largemouth bass fishery had an estimated worth of five million dollars to the local economy in 1986 (Milon et al. 1986).

The quality of the fisheries can be attributed in part to the diverse and abundant aquatic macrophytes supported in Orange Lake. Over 90 species of aquatic plants have been identified in Orange Lake during surveys from 1988 to 2006 (DEP, unpublished data), where aquatic plant coverage has ranged from 20% to nearly 100% of the lake area. Vegetation variety and density has been shown to influence fish and invertebrate assemblages by providing food resources (Moxley and Langford 1985) and refugia (Barnett and Schneider 1978), thus increasing ecosystem stability (Boyd 1971) for fishes. In particular, the plant species associated with the deep and shallow marsh habitats identified by Bryan and Warr (1998) provide the majority of the cover, forage, and spawning areas for the game and non-game fishes in Orange Lake. One plant species that has the potential to dominate the composition of these habitats, as well as open water, is hydrilla. Hydrilla became naturalized in the lake in 1974, and can positively or negatively influence the sport fish populations depending on lake coverage and density. Tate et al. (2003) found that the relative abundance of age-0 largemouth bass was positively related with the percentage of areal hydrilla coverage in Orange Lake. However, decreased growth and condition of adult largemouth bass can also occur at extremely high levels (Colle and Shireman 1980).

The sunfish family (Centrarchidae) encompasses the majority of the angling effort in Orange Lake, which includes largemouth bass, panfish, and black crappie, but this family also includes non-game species of the *Lepomis*, *Acantharchus*, and *Enneacanthus* genera. Although members of this family are commonly considered habitat and forage generalist (Boschung and Mayden 2004), habitat management for this family is ideal because it is comprised of a top-level piscivore (largemouth bass), insectivorous fishes such as bluegill (*Lepomis macrochirus*), and zooplanktivorous fishes such as bluespotted sunfish (*Enneacanthus gloriosus*). In addition, sunfishes are distributed throughout several habitats in the lake, namely the deep marsh, shallow marsh, and open water portions of the lake. Thus, sport fish members of the sunfish family (e.g., largemouth bass) may serve as an indicator of ecological stability, and management of these habitats should be protective of non-game species in their and other fish families.

The fish goals and objectives described herein focus primarily on the optimum cover and foraging habitat for Centrarchid fishes, which may generally be described as a mosaic of sparse and dense rooted emergent plant species and a mixture of submersed species. Optimum density is critical to predator-prey interactions and good growth of Centrarchid fish species. A robust forage population depicted by diverse sizes and species of fishes, amphibians, and invertebrates is assumed to be facilitated by fish habitat management goals and objectives.

Focal taxa goals

Maintain or enhance deep freshwater marsh habitat to perpetuate abundant and optimally structured Centrarchid populations in Orange Lake.

Rationale: Protection of habitats suitable for diverse Centrarchid populations will protect non-game fish populations. Lakes within the OCB are best characterized as deep freshwater marshes as defined in Florida's Wildlife Legacy Initiative.

Objectives - based on habitat types

Shallow marsh

Manage indefinitely shallow marsh areas for a mosaic of 50-75% rooted emergent vegetation (Table A 12). Lake wide objectives for floating marsh coverage needed to maintain connectivity to deep marsh habitats are 20-25% for Orange Lake, 10-25% for Lochloosa Lake, and 1-10% for Newnans Lake (Tables A 12 and A 13).

Deep marsh

Manage indefinitely the deep marsh areas of Orange Lake to provide 40-60% coverage of rooted emergent and submersed vegetation (<20 kg/m^2), and limit the coverage of floating marsh in this habitat type to less than 10%.

Floating islands and floating marsh

Limit floating islands and floating marshes to less than 15% of the total lake acreage, to less than 10% of deep marsh habitat block area, and less than 25% of shallow marsh habitat block area.

Shrub swamps and tree islands

Limit shrub swamps and tree islands each to less than 5% of the lake area.

Open water

Manage indefinitely the defined open water areas of Orange Lake to less than 5% surface coverage of hydrilla or less than 20% surface coverage of native SAV.

Table A 12. Fish focal taxa goals for Orange Lake.

Habitat type	Total target area of habitat type (percent of lake)	Degree of interspersion	Block size	Percent vegetation coverage	Density	Location
Shallow marsh	20-25%	A diverse, dense community of shallow marsh vegetation distributed within the block containing open areas and pockets of sparse vegetation.	200-500 acres (81-202 ha)	50-75% rooted emergent vegetation, No more than 25% of floating marsh.	20-30 kg/m2 (best judgment from KCOL plan)	6 defined areas: PG run, NW, NE, SE, SW quads, shallow perimeter of west arm
Deep marsh	10-20%	A mosaic of Egyptian paspalidium (*Paspalidium geminatum*) clumps greater than 1/8 of an acre (50 ft x 100 ft; 0.05 ha) irregularly distributed within the block. A mosaic of spatterdock clumps greater than 1/16 of an acre (50 ft x 50 ft; 0.025 ha) irregularly distributed within the block. With some topped-out SAV.	300-400 acre (121-162 ha)	40-60 % rooted emergent vegetation. 20-100% SAV –100 % OK if it's not all topped out. 10 % max of floating marshes	4-20 kg/m2 for rooted emergent vegetation and SAVs (best judgment from Kissimmee Chain of Lakes (KCOL) plan).	7 defined quadrants: SW, SE, S, NE, NW, PG, west arm
Floating island	<10%	N/A	N/A	N/A	N/A	N/A
Floating marsh	<10%	N/A	N/A	N/A	N/A	N/A
Shrub swamp	<5%	N/A	N/A	N/A	N/A	N/A
Tree island	<5%	N/A	N/A	N/A	N/A	N/A
Open water	40-50%	Minimal topped out SAV in the open water and adjacent to the deep marsh contact zone.	N/A	0-5% topped out hydrilla, 0-20% topped out native SAV	4-15 kg/m2 (best judgment from KCOL plan)	N/A
SAV	<40%	N/A	N/A	N/A	N/A	N/A

Table A 12. Continued.

Habitat type	Preferred vegetation species (in order of importance)	Preferred substrate	Focal taxa strategies
Shallow marsh	Shallow marsh species described in Bryan and Warr (1998). Monocultures should generally be avoided.	Loamy soil – mixture of organic soils and sand.	Mechanically cutting trails for connectivity to deep marsh and to minimize vast areas of dense marsh, Burning, Rotovator/tiller, Herbicide for trails, and Floating marsh harvesting
Deep marsh	Spatterdock, Egyptian paspalidium, native SAV, Hydrilla	Loamy soil – mixture of organic soils and sand.	Arial herbicide application, Herbicide application on floating herbaceous vegetation during high water, Mechanically cut trails, Mechanical harvesting of floating marshes at the open water deep marsh interface (if the percent coverage within the block is greater than 10%), and Vegetation planting of Egyptian paspalidium.
Floating island	Can use sub-habitat types	N/A	Mechanical cutter reduction or mechanical harvesting
Floating marsh	Can use sub-habitat types	N/A	herbicides and/or mechanical harvesting
Shrub swamp	Can use sub-habitat types	N/A	N/A
Tree island	Can use sub-habitat types	N/A	N/A
Open water	Native SAVs	N/A	Large scale treatment (if necessary), Large scale spot treatments; large scale trail system
SAV	N/A	N/A	N/A

Table A 13. Fish focal taxa goals for total target area of habitat type (percent of lake) on Lochloosa Lake and Newnans Lake.

Habitat type	Lochloosa Lake	Newnans Lake
Shallow marsh	10–25%	1-10%
Deep marsh	5–20%	1-20%
Floating island	0–10%	0–10%
Floating marsh	0–10%	0–10%
Shrub swamp	0–5%	0–5%
Tree island	0–5%	0–5%
Open water	50-75%	70-95%
SAV	N/A	N/A

Literature cited

Barnett, B. S. and R. W. Schneider. 1978. Fish populations in dense submersed plant communities. Hyacinth Control Journal 12:12–14.

Boschung, H. T. and R. L. Mayden. 2004. Fishes of Alabama. Smithsonian Books. Washington, D.C.

Boyd, C. E. 1971. The limnological role of aquatic macrophytes and their relationships to reservoir management. Pages 153–166 *in* G. E. Hall, editor. Reservoir fisheries and limnology. American Fisheries Society, Special Publication 8. Bethesda, Maryland.

Bryan, J. and K. Warr. 1998. Unpublished data. Report on Floating and Emergent Marsh Vegetation of Orange Lake, Florida. Draft internal report. Environmental Science Division. St. Johns River Water Management District, Palatka, Florida.

Colle D.E. and J.V. Shireman. 1980. Coefficients of condition for largemouth bass, bluegill, and redear sunfish in hydrilla infested lakes. Transactions of the American Fisheries Society. 109:521-531.

Milon, J.W., J. Yingling, and J.E. Reynolds. 1986. An economic analysis of the benefits of aquatic weed control in north-central Florida, with special reference to Orange and Lochloosa Lakes. In Annual Report USDA/APS-IFAS/UF: Integrated management of aquatic weeds. Ed. J.C. Joyce. Economics Report 113, University of Florida, Institute of Food and Agricultural Sciences. Gainesville, Florida.

Moxley, D. J. and F. H. Langford. 1985. Beneficial effects of hydrilla in two eutrophic lakes in central Florida. Proceedings of the Southeastern Association of Fish and Wildlife Agencies 36/1982:280–286.

Tate, W. B., M. S. Allen, R. A. Myers, E. J. Nagid, and J. Estes. 2003. Relation of age-0 largemouth bass abundance to hydrilla coverage and water levels at Lakes Lochloosa and Orange, Florida. North American Journal of Fisheries Management 23:251–257.

APPENDIX B: INVERTEBRATE ASSEMBLEGES

Eric Nelson and Gary L. Warren, FWRI Freshwater Fisheries Research – Invertebrates

Invertebrate assemblages

A detailed survey for aquatic invertebrate species composition and distribution has not been performed within the Orange Creek Basin. Macroinvertebrates have been sampled at Orange Lake (Schraam et al. 1983, Watkins et al. 1983, Haag et al. 1987) and Lochloosa Lake (Tuten 2007) as part of vegetation, fisheries, or bird studies. Presented is a description of the probable invertebrate assemblages within the major habitat types.

Tree island/hardwood swamp

Tree islands and hardwood swamps are typically dominated by mature trees and are only periodically inundated with water depths rarely exceeding 3.3 feet (1.0 meter). Invertebrate assemblages within this habitat would include: snails (Gastropoda); clams (Pelecypoda); segmented worms (Annelida); leeches (Hirundinia); mites (Hydracarina); scuds (Amphipoda); waterlice and slaters (Isopoda); crayfish (Decapoda); springtails (Collembola); mayflies (Ephemeroptera); dragonflies and damselflies (Odonata); half wings (Hemiptera); alderflies, dobsonflies and fishflies (Megaloptera); caddisflies (Trichoptera); butterflies and moths (Lepidoptera); beetles (Coleoptera); true flies (Diptera); and semi-aquatic or terrestrial taxa.

Shrub swamp

Shrub swamps are dominated by small trees and shrubs, intermixed with other (understory) wetland vegetation. Water depths are typically 1.6 to 4.9 feet (0.5 to 1.5 meters). No invertebrate data available, but taxonomic composition should be similar to the tree islands and hardwood swamps assemblage.

Shallow marsh

Shallow marshes are dominated by rooted emergent vegetation, often intermixed with submersed aquatic vegetation (SAV) or hydrilla (*Hydrilla verticillata*). Water depths are typically less than 4.9 feet (1.5 meters). Invertebrate assemblages within this habitat would include: sponges (Porifera); hydras (Hydrozoa); free-living flatworms (Turbellaria); ribbon worms (Nemertea); round worms (Nematoda); goblet worms (Entoprocta); moss animals (Ectoprocta); snails; clams; segmented worms; leeches; mites; scuds; waterlice and slaters; crayfish; springtails; mayflies; dragonflies and damselflies; half wings; caddisflies; butterflies and moths; sawflies, wasps, bees, and ants (Hymenoptera); beetles; and true flies.

Floating marsh

Floating marshes are composed of native or exotic plants growing on a buoyant mat consisting of plant roots and organic matter. Floating marshes are attached to the shoreline (i.e., not free-floating) and typically occur near the eco-tone of the shallow and deep marshes. Water depths are typically 3.3 to 9.8 feet (1.0 to 3.0 meters). Invertebrate assemblages within this habitat would include: moss animals, snails, scuds, waterlice and slaters, crayfish, dragonflies and damselflies, half wings, butterflies and moths, beetles, true flies, and semi-aquatic or terrestrial taxa.

Floating island

Floating islands have the same characteristics as floating marshes, but are free-floating. They are typically found in water depths greater than 3.3 feet (1.0 meter). Invertebrate assemblages within this habitat would be similar to floating marsh.

Deep marsh

Deep marshes are composed of rooted emergent and/or floating-leaved vegetation, often intermixed with SAV or hydrilla. Deep marshes are typically located lake-ward of the shallow marsh/floating marsh complex in water depths of 3.3 to 8.2 feet (1.0 to 2.5 meters). Invertebrate assemblages within this habitat would include: stinging nettles (Cnidaria), free-living flatworms, round worms, snails, clams, segmented worms, leeches, mites, scuds, waterlice and slaters, crayfish, springtails, mayflies, dragonflies and damselflies, half wings, caddisflies, butterflies and moths, beetles, and true flies.

Submersed aquatic vegetation

SAV habitat is a sub-category of deep marsh and is dominated by native (e.g., coontail (*Ceratophyllum demersum*), southern naiad (*Najas guadalupensis*)) and/or exotic (hydrilla) submersed plants, with little or no other vegetation present. While native SAV typically occurs in water depths of less than 6.6 feet (2.0 meters), hydrilla can potentially grow in all areas of Orange Lake. Invertebrate assemblages within this habitat would include: sponges; hydras; free-living flatworms; ribbon worms; round worms; goblet worms; moss animals; snails; clams; segmented worms; leeches; mites; scuds; waterlice and slaters; crayfish; springtails; mayflies; dragonflies and damselflies; half wings; caddisflies; butterflies and moths; sawflies, wasps, bees, and ants; beetles; and true flies.

Hydrilla

Hydrilla is an exotic submersed plant, with little or no other vegetation present. Hydrilla can potentially grow in all areas of Orange Lake. Invertebrate assemblages within this habitat would include: free-living flatworms, round worms, snails, clams, segmented worms, leeches, mites, scuds, waterlice and slaters, crayfish, springtails, mayflies, dragonflies and damselflies, half wings, caddisflies, butterflies and moths, beetles, and true flies.

Open water

Open water areas are devoid of vegetation, generally occurring in the middle, limnetic region of the lake. Open water depths typically range from 4. 9 to 9.8 feet (1.5 to 3.0 meters). Invertebrate assemblages within this habitat would include: sponges, hydras, free-living flatworms, ribbon worms, round worms, goblet worms, moss animals, snails, clams, segmented worms, leeches, mites, scuds, waterlice and slaters, crayfish, springtails, mayflies, dragonflies and damselflies, stoneflies (Plecoptera), half wings, caddisflies, butterflies and moths, beetles, and true flies.

Literature cited

Haag, K. H., J.C. Joyce, W.M. Hetrick, and J. C. Jordan. 1987. Predation on waterhyacinth weevils and other aquatic insects by three wetland birds in Florida. Florida Entomologist 70(4):457-471.

Schramm, H.L., Jr., M.V. Hoyer, K.J. Jirka. 1983. Relative ecological value of common aquatic plants. Final report submitted to Bur. Aquat. Plant Res. Contr., Florida Department of Natural Resources, Tallahassee, FL.

Tuten, M.T. 2007. Diet composition and growth rates of black crappie Pomoxis nigromaculatus relative to benthic food availability at three Florida lakes. Master's thesis, University of Florida. Gainesville, Florida.

Watkins, C.E., II, J.V. Shireman, and W.T. Haller. 1983. The influence of aquatic vegetation upon zooplankton and benthic invertebrates in Orange Lake, Florida. J. Aquatic Plant Management. 21:78-83.

APPENDIX C: HABITAT CLASSIFICATION USED IN GIS ANALYSES

Craig Mallison, FWRI Freshwater Plants Research

Littoral vegetation was mapped within the Orange Creek Basin (OCB) lakes during 2007, 2010, 2013, 2016, 2019 and 2022 as detailed in the GIS Habitat Analysis section. Polygons were classified according to an amended version of the *Florida Land Use, Cover and Forms Classification System* (FLUCFCS). Reclassification of polygons was required to utilize the habitat classifications detailed in this document (Table C 1). Polygons were considered adjacent to the lake boundary when half or more of the polygon border did not extend into the lake basin. Photo-interpretation of 2007 and 2010 imagery was used to define a standard boundary on Orange Lake where herbaceous vegetation was within a floating zone or rooted zone, and this boundary was used for all analyses to estimate the amount of floating and rooted vegetation.

Table C 1. OCB habitat classification, corresponding FLUCFCS classes, and reclassification conditions for GIS analysis of littoral vegetation maps.

OCB habitat classification	FLUCFCS code and common name	Classification condition
0 – omit from analysis	1000 Upland	Polygons with no trees evident in the aerial imagery and occurring outside of the lake boundary
5200 - Open water	5200 Lakes	All polygons except areas intersecting with submersed aquatic vegetation (SAV) that was mapped using hydroacoustic methods
6100 - Hardwood swamp	1000 Upland	Polygons with large trees evident in the aerial imagery, and adjacent to the lake boundary or islands
6100 - Hardwood swamp	6100 Wetland forests and shrubs, 6200 Cypress, 6301 Other wetland forests	Polygons adjacent to the lake boundary or islands
6101 - Tree island	1000 Upland	Polygons with large trees evident in the aerial imagery, and not attached or adjacent to the lake boundary or islands
6101 - Tree island	6100 Wetland forests and shrubs, 6200 Cypress, 6301 Other wetland forests	Polygons not attached or adjacent to the lake boundary or islands
6181 - Willow swamp	6181 Willow	All polygons attached to shoreline vegetation (i.e., not surrounded by open water, SAV, and/or deep marsh)
6181 - Willow swamp	6425-6181 American cupscale grass - Willow	Polygons displaying willow as the dominant signature and attached to shoreline vegetation
6410 - Complex floating marsh	6410 Freshwater marshes / Graminoid prairie - marsh, 6412 Cattail, 6414 Maidencane / Egyptian paspalidium, 6415 Dog fennel, 6419 Smartweed, 6420 Pickerelweed / arrowhead, 6421 Bulrush, or mixed classes dominated by these plants	Polygons attached to shoreline vegetation and occurring within the floating zone (except for 6414 polygons displaying deep grass marsh signatures)

Table C 1. Continued.

OCB habitat classification	FLUCFCS code and common name	Classification condition
6412 - Tall linear-leaved shallow marsh	6411 Sawgrass	All polygons
6412 - Tall linear-leaved shallow marsh	6412 Cattail	Polygons occurring within the rooted zone
6412 - Tall linear-leaved shallow marsh	6412-6414 Mixed cattail - maidencane / Egyptian paspalidium	Polygons displaying cattail as the dominant signature and occurring within the rooted zone
6412 - Tall linear-leaved shallow marsh	6412-6420 Mixed cattail - pickerelweed / arrowhead	Polygons displaying cattail as the dominant signature and occurring within the rooted zone
6412 - Tall linear-leaved shallow marsh	6421 Bulrush	Polygons occurring within the rooted zone
6412 - Tall linear-leaved shallow marsh	6421-6442 Mixed bulrush - spatterdock	Polygons displaying bulrush as the dominant signature and occurring within the rooted zone
6414 - Maidencane shallow marsh	6412-6414 Mixed cattail - maidencane / Egyptian paspalidium	Polygons displaying maidencane as the dominant signature and occurring within the rooted zone
6414 - Maidencane shallow marsh	6414 Maidencane / Egyptian paspalidium	Polygons occurring within the rooted zone
6417 - Mixed shrub swamp	6417 Freshwater marsh with shrubs, brush, and/or vines	All polygons attached to shoreline vegetation
6417 - Mixed shrub swamp	6425-6181 American cupscale grass - willow	Polygons displaying ≥50% shrubs and trees
6420 - Flag shallow marsh	6420 Pickerelweed / arrowhead	Polygons occurring within the rooted zone
6420 - Flag shallow marsh	6420-6424 Mixed pickerelweed / arrowhead - water primrose / knotweed	Polygons displaying pickerelweed / arrowhead as the dominant signature and occurring within the rooted zone
6422 - Grass deep marsh	6414 Maidencane / Egyptian paspalidium	Polygons occurring within the floating zone that exhibit signature consistent with grass deep marsh
6422 - Grass deep marsh	6414-6442 Mixed maidencane / Egyptian paspalidium - spatterdock	Polygons displaying maidencane / Egyptian paspalidium as the dominant signature and occurring within the floating zone
6422 - Grass deep marsh	6414-6446 Mixed maidencane / Egyptian paspalidium - American lotus	Polygons displaying maidencane / Egyptian paspalidium as the dominant signature and occurring within the floating zone
6424 - Low floating marsh	6424 Water primrose / knotweed 6425 American cupscale grass, 6424-6425 Mixed water primrose / knotweed - American cupscale grass, 6444 Duckweed / floating vegetation	Polygons attached to shoreline vegetation and occurring within the floating zone

Table C 1. Continued.

OCB habitat classification	FLUCFCS code and common name	Classification condition
6424 - Low floating marsh	6420-6424 Mixed pickerelweed / arrowhead - water primrose / knotweed, 6424-6442 Mixed water primrose / knotweed - Spatterdock	Polygons displaying water primrose / knotweed as the dominant signature and occurring within the floating zone
6424 - Low floating marsh	6425-6181 Mixed water primrose / knotweed – willow	Polygons displaying American cupscale grass as the dominant signature and occurring within the floating zone
6430 - Mixed shallow marsh	1000 Upland	Polygons without trees evident in the aerial imagery, and within lake basin (exposed due to low water)
6430 - Mixed shallow marsh	6410 Freshwater marshes / Graminoid prairie marsh, 6415 Dog Fennel, 6424 Water primrose / knotweed, 6425 American cupscale grass, 6424-6425 Mixed water primrose / knotweed - American cupscale grass	Polygons occurring occurring within the rooted zone
6440 - Floating island	6181 Willow, 6410 Freshwater marshes / Graminoid prairie - marsh, 6412 Cattail, 6414 Maidencane / Egyptian paspalidium, 6415 Dog fennel, 6417 Freshwater marsh with shrubs, brush, and/or vines, 6420 Pickerelweed / arrowhead, 6421 Bulrush, 6424 Water primrose / knotweed, 6425 American cupscale grass, or mixed classes dominated by these plants	Polygons not attached to shoreline vegetation or rooted islands
6442 - Floating-leaved deep marsh	6414-6442 Mixed maidencane / Egyptian paspalidium – spatterdock, 6420-6442 Mixed pickerelweed / arrowhead – spatterdock, 6424-6442 Mixed water primrose / knotweed – spatterdock	Polygons displaying spatterdock as the dominant signature
6442 - Floating-leaved deep marsh	6442 Spatterdock, 6445 Lilies (water lily and/or banana lily), 6446 American lotus, and mixed classes dominated by these plants	All polygons
6450 - SAV	5200 Lakes, 6444 Duckweed / floating vegetation	Polygons that intersected with SAV that was mapped using hydroacoustic methods
6450 - SAV	6450 - SAV	All polygons

APPENDIX D: ORANGE LAKE HABITAT EVALUATIONS 2007-2022

Craig Mallison, FWRI Freshwater Plants Research

METHODS

Habitat conditions for fish and wildlife on Orange Lake were evaluated using GIS analysis of vegetation maps created in 2007, 2010, 2013, 2016, 2019, and 2022 (Figure D 1). Mapping methods were described in the GIS HABITAT ANALYSIS section and reclassification in Appendix C. Additionally, submersed aquatic vegetation (SAV) data were obtained in 2010 from Remetrix and in 2017, 2019, and 2022 from FWC, and were included in habitat evaluations. The Orange Creek Basin Working Group ranked habitat value for each combination of dominant habitat type and coverage modifier (Table D 1). For each of the focal taxa, habitat value rankings were used to develop a GIS analysis that identified location and total area of usable habitat, including high-quality habitat (provides excellent conditions) and acceptable habitat (provides suitable conditions). All GIS analyses focused on dominant aquatic plant communities, plant coverage, and proximity to important habitat types. Where indicated, portions of polygons were selected based on location of habitat types relative to other habitat types, using buffer and clip tools in ArcGIS. For example, proximity to pockets of open water was critical for several analyses, and a condition was added to ensure that selected habitat was within a specified distance of "open-water classes" (defined as all polygons classified as open water, SAV, deep marsh, or other habitat types with a coverage modifier of S or M).

ALLIGATORS (*ALLIGATOR MISSISSIPPIENSIS*) - FORAGING

1. Area >16 ft (5 m) from open water classes was not selected as usable habitat. This represented all dense vegetation except deep marsh and SAV.
2. Polygons of a habitat type/coverage ranked "good" (Table D 1), excluding open water and SAV, were selected as high-quality habitat. This included shallow marsh except maidencane (*Panicum hemitomon*, S and M coverage), complex floating marsh (S, M), deep marsh (S, M), and floating island (S, M, D). Note this did not include portions of dense floating islands that were omitted in step 1.
3. SAV within 328 ft (100 m) of another habitat type was selected as high-quality habitat.
4. Open water within 328 ft of another habitat type was selected as high-quality habitat.
5. Remaining area not defined in steps 1-4 was selected as acceptable habitat.

ALLIGATORS - NESTING

GPS locations of alligator nests from 1998-2005 were plotted on top of the littoral vegetation map. Distances of nests to open water and tree islands were evaluated with sensitivity analysis to determine appropriate buffer distances for analyses.

1. Area >410 ft (125 m) from open water classes and >410 ft from small (≤12 acres [5 ha]) tree islands was omitted from analyses and thus not selected as usable habitat.
2. Polygons of a habitat type/coverage ranked "good" (Table D 1) were selected as high-quality habitat. This included tree island (D), tall linear-leaved shallow marsh (M, D), shallow marsh except tall linear-leaved (D), floating marsh (D), and floating island (D).
3. Polygons of a habitat type/coverage ranked "fair" (Table D 1) were selected as acceptable habitat. This included shrub swamp (D), tall linear-leaved shallow marsh (S), shallow marsh except tall linear-leaved (M), complex floating marsh (M), and floating island (M).

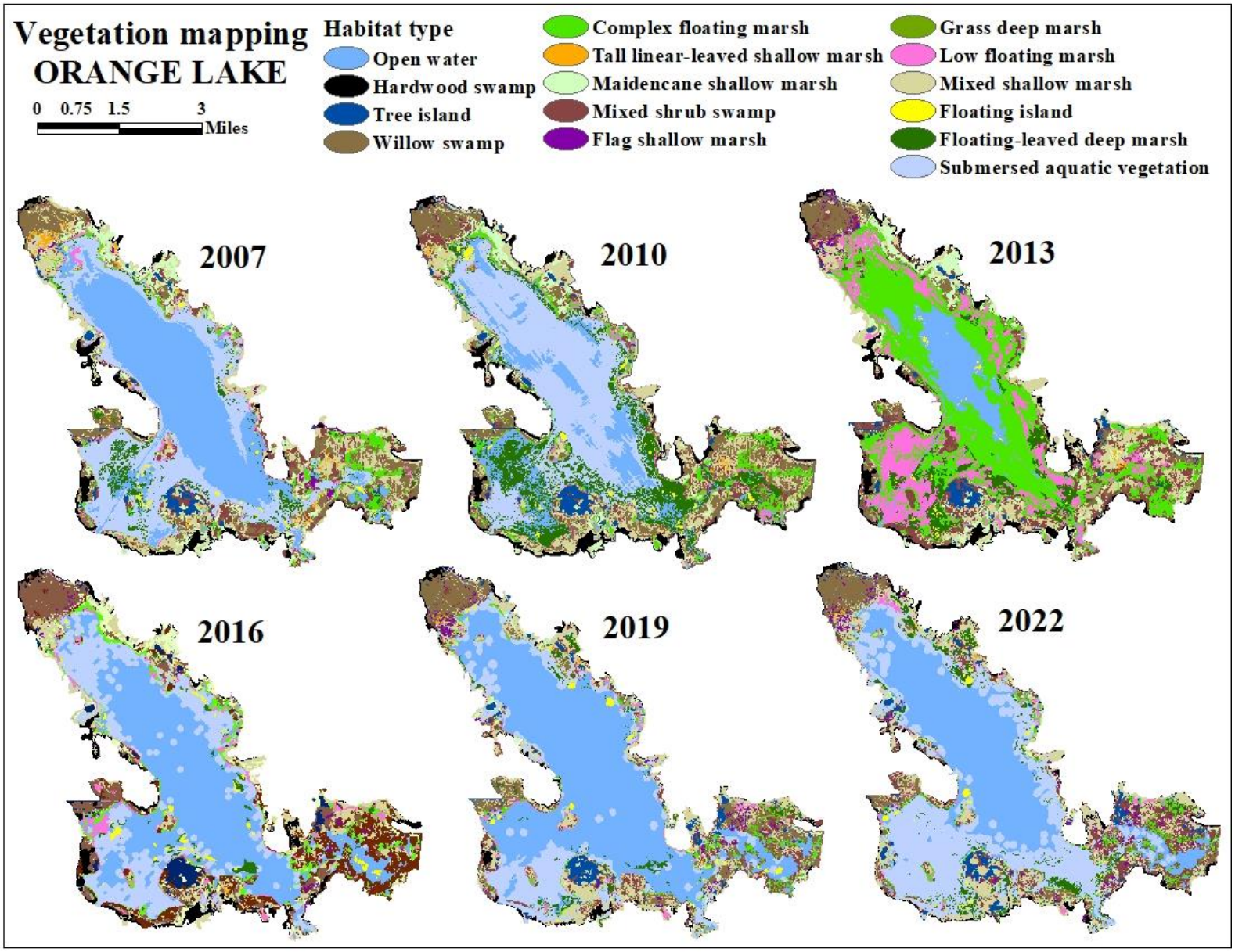

Figure D 1. Orange Lake littoral vegetation maps from 2007 to 2022.

Table D 1. Habitat value rank for each combination of dominant class (vegetation community class) and coverage modifier (sparse, 1-33% coverage; medium, 33-66% coverage; dense, 67-100% coverage).

		ALLIGATORS		HERPS	WADING BIRDS		MAMMALS	BALD EAGLE	WATERFOWL		FISH	
Habitat type	Habitat coverage	Foraging	Nesting	All	Foraging	Roosting	Foraging/ shelter	Nesting	Wood ducks	Ring-necked ducks	Black crappie	Largemouth bass
Hardwood swamp	Dense	fair	poor	fair	fair	fair	poor	fair	excellent	poor	poor-fair	poor
Tree island	Dense	fair	good	poor	fair	excellent	poor	fair	poor	poor	poor-fair	poor-fair
Willow shrub swamp	Dense	fair	fair	fair	fair	excellent	poor	poor	good-excellent	poor	poor-fair	poor-fair
Mixed shrub swamp	Dense	fair	fair	fair	fair	good	poor	poor	excellent	poor	poor-fair	poor-fair
Maidencane shallow marsh	Dense	fair	good	fair	poor	poor	excellent	poor	fair	poor	poor-fair	poor
	Medium	fair	fair	fair	fair	poor	excellent	poor	good	fair	poor-fair	poor-fair
	Sparse	fair	poor	poor	good	poor	good	poor	good	fair	poor-fair	poor
Tall linear-leaved shallow marsh	Dense	fair	good	fair	fair	good	good	poor	poor	poor	poor	poor
	Medium	good	good	fair	good	poor	fair	poor	good	good	fair	good
	Sparse	good	fair	poor	fair	poor	poor	poor	fair	good	good	fair
Flag shallow marsh	Dense	fair	good	fair	fair	poor	good	poor	good	poor	poor-fair	poor
	Medium	good	fair	fair	excellent	poor	fair	poor	excellent	fair	poor-fair	poor-fair
	Sparse	good	poor	poor	good	poor	poor	poor	good	good	poor-fair	poor
Mixed shallow marsh	Dense	fair	good	good	fair	poor	good	poor	good	fair	poor-fair	poor
	Medium	good	fair	good	excellent	poor	fair	poor	excellent	good	poor-fair	poor-fair
	Sparse	good	poor	good	good	poor	poor	poor	good	good	poor-fair	poor
Low floating marsh	Dense	fair	good	good	fair	poor	good	poor	poor	poor	poor-fair	poor-fair
Complex floating marsh	Dense	fair	good	good	poor	good	fair	poor	poor	poor	poor-fair	poor-fair
	Medium	good	fair	good	fair	poor	poor	poor	poor	poor	poor-fair	poor-fair
	Sparse	good	poor	fair	poor	poor	poor	poor	poor	poor	poor-fair	poor-fair
Floating -leaved deep marsh	Dense	fair	poor	fair	fair	poor	good	poor	excellent	excellent	poor-fair	fair
	Medium	good	poor	poor	poor	poor	fair	poor	good	excellent	fair	good
	Sparse	good	poor	poor	poor	poor	poor	poor	good	good	good	fair
Grass deep marsh	Dense	fair	poor	fair	fair	poor	good	poor	fair	poor	poor-fair	fair
	Medium	good	poor	fair	fair	poor	fair	poor	fair	fair	fair	good
	Sparse	good	poor	fair	fair	poor	poor	poor	fair	fair	good	fair
Floating Island	Dense	good	good	good	fair	poor	fair	poor	poor	poor	poor-fair	poor-fair
	Medium	good	fair	good	good	poor	poor	poor	poor	poor	poor-fair	poor-fair
	Sparse	good	poor	fair	fair	poor	poor	poor	poor	poor	poor-fair	poor-fair
Open water	Open water	good	poor	poor	fair	poor	poor	poor	good-excellent	good-excellent	good	fair
SAV	Sparse	good	poor	fair	good-fair	poor	poor	poor	good-excellent	good-excellent	poor-fair	fair-good

HERPETOFAUNA (REPTILES/AMPHIBIANS)

1. Polygons of a habitat type/coverage ranked "good" (Table D 1) were selected as high-quality habitat. This included mixed shallow marsh (S, M, D), floating marsh (M, D), and floating island (M, D). Additionally, all mapped area within 98 ft (30 m) of these was selected as high-quality habitat.
2. For remaining areas not selected as high-quality habitat in step 1: polygons of a habitat type/coverage ranked "fair" (Table D 1) were selected as acceptable habitat. This included hardwood swamp (D), shrub swamp (D), shallow marsh except mixed (M, D), complex floating marsh (S), floating-leaved deep marsh (D), grass deep marsh (S, M, D), floating island (S), and SAV. Additionally, all remaining mapped area within 98 ft of these was selected as acceptable habitat.

MAMMALS

Foraging and nesting: Round-tailed muskrat (*Neofiber allenii*) was the principal species in the mammal focal taxon. Maidencane shallow marsh is a critical habitat for round-tailed muskrats. Round-tailed muskrats tend to feed in relatively small areas (Birkenholz 1963) and home range estimates ranged from 0.25-0.5 acres (0.1-0.2 ha; Schooley and Branch 2006). To ensure adequate patch sizes of maidencane were selected, a minimum-patch requirement of 0.25 acres (0.1 ha) was applied in analyses.

1. Habitat type/coverage ranked "excellent" (Table D 1) included maidencane shallow marsh (M, D). For these, polygons ≥0.25 acres were selected as high-quality habitat; polygons <0.25 acres were evaluated with "good" habitat types in step 2.
2. Habitat type/coverage ranked "good" (Table D 1) included maidencane shallow marsh (S), shallow marsh except maidencane (D), low floating marsh (D), and deep marsh (D). For these (and for M or D maidencane shallow marsh polygons <0.25 acres in size, not selected in step 1), area within 328 ft (100 m) of high-quality habitat from step 1 was selected as high-quality habitat; remaining area within 328 ft of non open-water classes (i.e., dense vegetation) was selected as acceptable habitat.
3. Habitat type/coverage ranked "fair" (Table D 1) included shallow marsh except maidencane (M), complex floating marsh (D), deep marsh (M), and floating island (D). For these, area within 328 ft of high-quality or acceptable habitat from steps 1-2 *and* within 328 ft of non open-water classes was selected as acceptable habitat.

WADING BIRDS - FORAGING

1. All usable habitat was within 328 ft (100 m) of the open water edge (area >328 ft from either open water classes or emergent/woody vegetation was omitted from analyses).
2. In remaining areas not omitted in step 1, polygons of a habitat type/coverage ranked "excellent" or "good" (Table D 1) were selected as high-quality habitat. This included maidencane shallow marsh (S), tall linear-leaved shallow marsh (M), flag shallow marsh (S, M), mixed shallow marsh (S, M), and floating island (M).
3. In remaining areas not selected in step 1-2, polygons of a habitat type/coverage ranked "good-fair" or "fair" (Table D 1) were selected as acceptable habitat. This included hardwood swamp (D), tree island (D), shrub swamp (D), maidencane shallow marsh (M), tall linear-leaved shallow marsh (S, D), flag shallow marsh (D), mixed shallow marsh (D), low floating marsh (D), complex floating marsh (M), floating-leaved deep marsh (D), grass deep marsh (S, M, D), floating island (S, D), open water, and SAV.

WADING BIRDS - ROOSTING

1. Polygons of a habitat type/coverage ranked "excellent" (Table D 1) were selected as high-quality habitat. This included tree island (D) and willow (*Salix* sp.) shrub swamp (D).
2. Habitat type/coverage ranked "good" (Table D 1) included mixed shrub swamp (D), tall linear-leaved shallow marsh (D), and complex floating marsh (D). For these, area within 100 m of a "fair" or "poor" habitat type was selected as acceptable habitat; remaining area was selected as high-quality habitat.
3. Habitat type/coverage ranked "fair" (Table D 1) included hardwood swamp (D). For these, area within 328 ft (100 m) of high-quality or acceptable habitat from steps 1-2 was selected as acceptable habitat.

WATERFOWL - WOOD DUCKS (*AIX SPONSA*)

1. Habitat type/coverage ranked "excellent", "good-excellent", or "good" (Table D 1) included hardwood swamp (D), shrub swamp (D), maidencane shallow marsh (S, M), tall linear-leaved shallow marsh (M), flag shallow marsh (S, M, D), mixed shallow marsh (S, M, D), floating-leaved deep marsh (S, M, D), open water, and SAV. For all at coverage D: area within 98 ft (30 m) of open water classes was selected as high-quality habitat, and remaining area was held for analysis in step 2. For all at coverage M: all area was selected as high-quality habitat. For all at coverage S, open water, and SAV: area within 98 ft of M or D vegetation was selected as high-quality habitat, and remaining area was held for analysis in step 2.
2. For remaining area of habitat types/coverages specified in step 1: area within 98 ft of high-quality habitat selected in step 1 was selected as acceptable habitat.
3. Habitat type/coverage ranked "fair" (Table D 1) included maidencane shallow marsh (D), tall linear-leaved shallow marsh (S), and grass deep marsh (S, M, D). For all at coverage D: area within 98 ft of open water classes was selected as acceptable habitat. For all at coverage M: all area was selected as acceptable habitat. For all at coverage S: area within 98 ft of M or D vegetation was selected as acceptable habitat.
4. Habitat type/coverage ranked "fair" or "poor" (Table D 1) included tree island (D), maidencane shallow marsh (D), tall linear-leaved shallow marsh (S, D), floating marsh (S, M, D), grass deep marsh (S, M, D), and floating island (S, M, D). For all at coverage D: area was not selected as usable habitat (except where selected in step 2). For all at coverage S or M: area within 30 m of high-quality habitat was selected as acceptable habitat.

WATERFOWL - RING-NECKED DUCKS (*AYTHYA COLLARIS*)

1. Habitat type/coverage ranked "excellent" or "good-excellent" (Table D 1) included floating-leaved deep marsh (M, D), open water, and SAV. For these, area within 98 ft (30 m) of a habitat type/coverage ranked "fair" or "poor" was selected as acceptable habitat; remaining area was selected as high-quality habitat, except as described in step 4 for open water.
2. Habitat type/coverage ranked "good" (Table D 1) included tall linear-leaved shallow marsh (S, M), flag shallow marsh (S), mixed shallow marsh (S, M), and floating-leaved deep marsh (S). For these, area within 30 m of high-quality habitat (from step 1) and

more than 98 ft from a habitat type/coverage ranked "fair" or "poor" was selected as high-quality habitat; remaining area was selected as acceptable habitat.

3. Habitat type/coverage ranked "fair" (Table D 1) included maidencane shallow marsh (S, M), flag shallow marsh (M), mixed shallow marsh (D), and grass deep marsh (S, M). For these, area within 98 ft of habitat from steps 1-2 was selected as acceptable habitat.
4. Open water within 328 ft (100 m) of high-quality habitat from steps 1-2 was selected as high-quality habitat. Remaining water that was A) within 328 ft of high-quality or acceptable habitat from steps 1-3, or B) within 328 ft of open water selected as high-quality habitat in step 4, was selected as acceptable habitat.

FISH - BLACK CRAPPIE (*POMOXIS NIGROMACULATUS*)

1. Area >98 ft (30 m) from open water classes was omitted from analyses and thus not selected as usable habitat.
2. Polygons of a habitat type/coverage ranked "good" (Table D 1) were selected as high-quality habitat. This included tall linear-leaved shallow marsh (S), deep marsh (S), and open water.
3. Polygons of a habitat type/coverage ranked "fair" or "poor-fair" (Table D 1) were selected as acceptable habitat. This included hardwood swamp (D), tree island (D), shrub swamp (D), tall linear-leaved shallow marsh (M), shallow marsh except tall linear-leaved (S, M, D), floating marsh (S, M, D), deep marsh (M, D), floating island (S, M, D), and SAV.

FISH - LARGEMOUTH BASS (*MICROPTERUS SALMOIDES*)

1. Area >98 ft (30 m) from open water classes was omitted from analyses and thus not selected as usable habitat.
2. Polygons of a habitat type/coverage ranked "good" (Table D 1) were selected as high-quality habitat. This included tall linear-leaved shallow marsh (M) and deep marsh (M).
3. For SAV (ranked "fair-good" in Table D 1), area within 98 ft of a habitat type/coverage ranked "good" or "fair" was selected as high-quality habitat, and remaining area was selected as acceptable habitat.
4. Polygons of a habitat type/coverage ranked "fair" (Table D 1) included tall linear-leaved shallow marsh (S), deep marsh (S, D), and open water. For all except open water, area within 98 ft of a habitat type/coverage ranked "good" or "fair-good" was selected as high-quality habitat, and remaining area was selected as acceptable habitat. For open water, area within 98 ft of a habitat type/coverage ranked "good" or "fair-good" was selected as high-quality habitat; area within 98 ft of open water selected as high-quality habitat was selected as acceptable habitat; and remaining area within 98 ft of a habitat type/coverage ranked "fair" or "poor-fair" was selected as acceptable habitat.
5. Habitat type/coverage ranked "poor-fair" (Table D 1) included tree island (D), shrub swamp (D), shallow marsh except tall linear-leaved (M), floating marsh (S, M, D), and floating island (S, M, D). For these, area within 98 ft of high-quality or acceptable habitat from steps 2-4 was selected as acceptable habitat.

BALD EAGLE (*HALIAEETUS LEUCOCEPHALUS*)

Nesting: Bald eagle nests that occurred within 1.6 mile (2.5 km; approximate radius of territory size) of the Orange Lake footprint were isolated from the 2011 bald eagle database

(https://public.myfwc.com/FWRI/EagleNests/nestlocator.aspx). Nesting locations from this subset were buffered by the minimum disturbance distance of 660 ft (200 m). Buffered locations were highlighted to indicate caution: any management actions in these areas must not take place during nesting season. Conditions for bald eagle foraging were adequately specified within the fish group.

COMBINED ANALYSIS

Results for all focal taxa analyses were combined to evaluate lake wide habitat value on Orange Lake in 2007, 2010, 2013, 2016, 2019, and 2022. GIS analysis (union tool) was used to identify all areas that were selected for each combination of focal taxa and habitat category (high-quality or acceptable). Each area scored one point for each taxon that selected the area as acceptable habitat, and two points for each taxon that selected the area as high-quality taxa. Overall habitat value was ranked high for areas that scored eight or more points; medium for areas with six or seven points; and low for areas scoring five or fewer points. Results were also used to determine overlap in habitat selection for focal taxa.

RESULTS

Results for individual focal taxa analyses on Orange Lake (2007, 2010, 2013, 2016, 2019, and 2022) are presented in Tables D 2-11 and Figures D 2-11. Results for focal taxa analyses were combined to rank the overall habitat value on Orange Lake in each mapping year (Figure 6, not duplicated in Appendix D). There was considerable overlap in classification of suitable habitat for focal taxa. For example, ≥75% of the area selected as high-quality wading bird foraging habitat was also selected as usable habitat for 5 of the 9 other focal taxa (Table D 12). Creating additional high-quality wading bird foraging habitat will also create additional usable habitat for several other focal taxa. The least overlap was observed for high-quality black crappie habitat, where ≤ 25% was selected as usable habitat for 6 of the 9 other focal taxa. Creating additional high-quality black crappie habitat will create little usable habitat for the other focal taxa. These data may be useful in developing management plans and for predicting effects of proposed management on habitat quality for focal taxa.

Table D 2. Area (acres) of high-quality and acceptable habitat per habitat type for alligator foraging in Orange Lake, based on GIS analysis of vegetation maps produced from 2007 to 2022.

Orange Lake	Alligator foraging					
Habitat type	**2007**	**2010**	**2013**	**2016**	**2019**	**2022**
High-quality habitat						
Open water	1,322	1,483	602	2,048	2,129	1,362
Hardwood swamp						
Tree island						
Willow shrub swamp						
Complex floating marsh	37	29	885			<1
Tall linear-leaved shallow marsh	<1					
Maidencane shallow marsh						
Mixed shrub swamp						
Flag shallow marsh						<1
Grass deep marsh		1				
Low floating marsh						
Mixed shallow marsh	1	41	<1	19	45	26
Floating island	33	37	30	41	25	26
Floating-leaved deep marsh	163	721	51	108	142	338
Submersed aquatic vegetation	2,571	2,554	19	2,184	1,617	3,143
Sub-total high-quality habitat	**4,128**	**4,866**	**1,586**	**4,401**	**3,958**	**4,896**
Acceptable habitat						
Open water	2,732	86	534	2,432	3,869	2,488
Hardwood swamp	1	3	<1	4	6	6
Tree island	2	1	<1	3	7	9
Willow shrub swamp	11	12	<1	13	37	27
Complex floating marsh	46	36	261	58	42	51
Tall linear-leaved shallow marsh	<1	<1		<1	1	1
Maidencane shallow marsh	2	11		14	9	5
Mixed shrub swamp	12	11	4	51	46	52
Flag shallow marsh	<1	<1		1	7	8
Grass deep marsh		<1				
Low floating marsh	66	77	180	73	50	54
Mixed shallow marsh	14	16	<1	56	119	130
Floating island						
Floating-leaved deep marsh	366	1,016	606	29	108	210
Submersed aquatic vegetation	318	1,235		369	276	832
Sub-total acceptable habitat	**3,572**	**2,504**	**1,586**	**3,102**	**4,577**	**3,873**
Total habitat	**7,699**	**7,370**	**3,173**	**7,503**	**8,535**	**8,769**

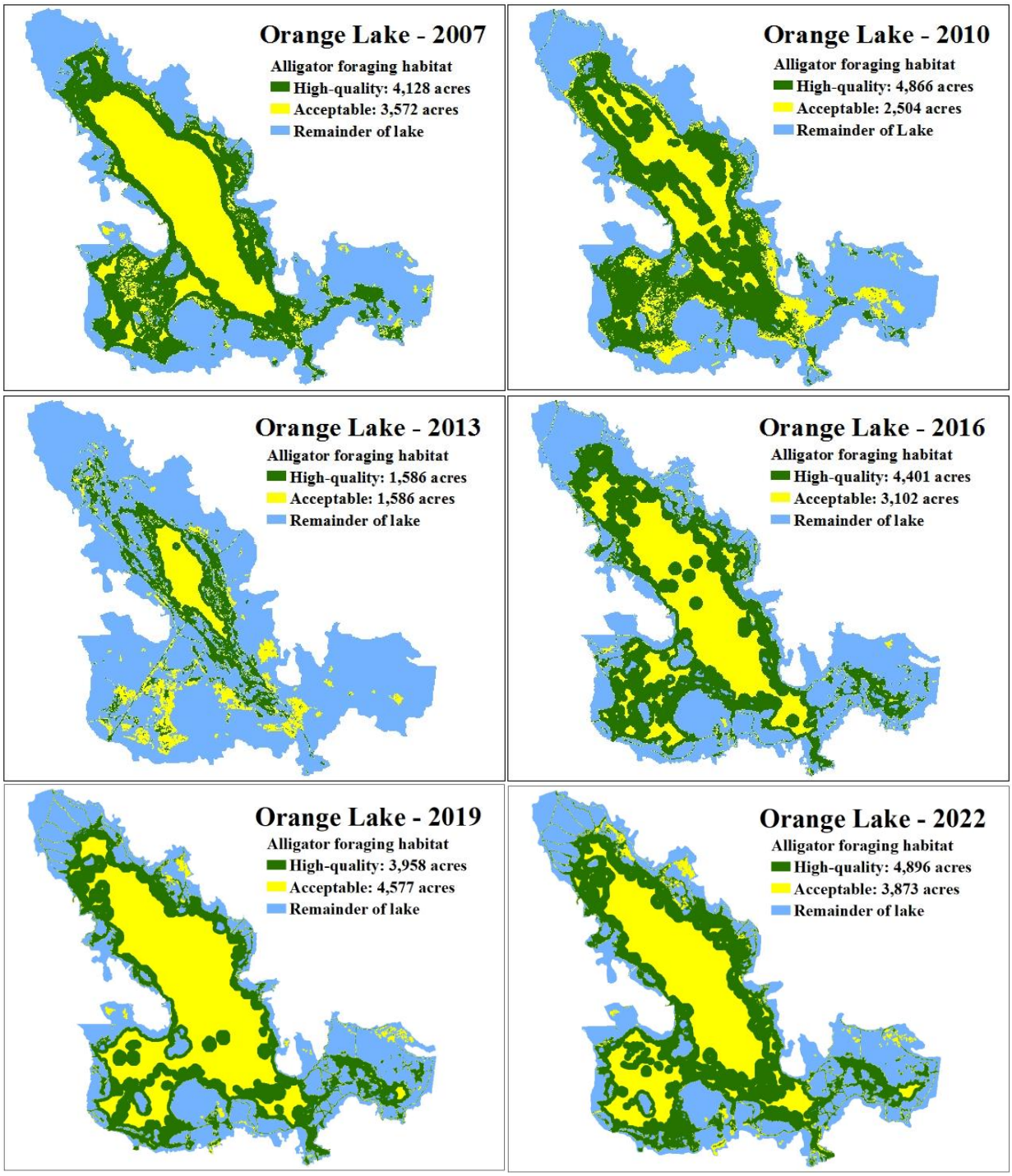

Figure D 2. Location of alligator foraging habitat identified with GIS analysis of vegetation maps on Orange Lake from 2007 to 2022.

Table D 3. Area (acres) of high-quality and acceptable habitat per habitat type for alligator nesting in Orange Lake, based on GIS analysis of vegetation maps produced from 2007 to 2022.

Orange Lake	Alligator nesting					
Habitat type	**2007**	**2010**	**2013**	**2016**	**2019**	**2022**
High-quality habitat						
Open water						
Hardwood swamp						
Tree island	146	156	172	151	217	224
Willow shrub swamp						
Complex floating marsh	293	551	2,462	472	317	316
Tall linear-leaved shallow marsh	32	15	4	10	35	28
Maidencane shallow marsh	312	218	217	391	179	99
Mixed shrub swamp						
Flag shallow marsh	34	13	34	39	142	172
Grass deep marsh						
Low floating marsh	268	269	1,341	371	205	194
Mixed shallow marsh	785	843	446	679	1,307	1,352
Floating island	85	107	40	136	88	68
Floating-leaved deep marsh						
Submersed aquatic vegetation						
Sub-total high-quality habitat	**1,956**	**2,173**	**4,718**	**2,249**	**2,489**	**2,452**
Acceptable habitat						
Open water						
Hardwood swamp						
Tree island						
Willow shrub swamp	485	669	260	588	837	577
Complex floating marsh	35	27	554			<1
Tall linear-leaved shallow marsh						
Maidencane shallow marsh		9				
Mixed shrub swamp	410	424	516	934	627	871
Flag shallow marsh						<1
Grass deep marsh						
Low floating marsh						
Mixed shallow marsh	1	40	<1	15	43	9
Floating island	1	4	7	2	<1	5
Floating-leaved deep marsh						
Submersed aquatic vegetation						
Sub-total acceptable habitat	**933**	**1,173**	**1,338**	**1,539**	**1,507**	**1,463**
Total habitat	**2,889**	**3,346**	**6,056**	**3,787**	**3,995**	**3,915**

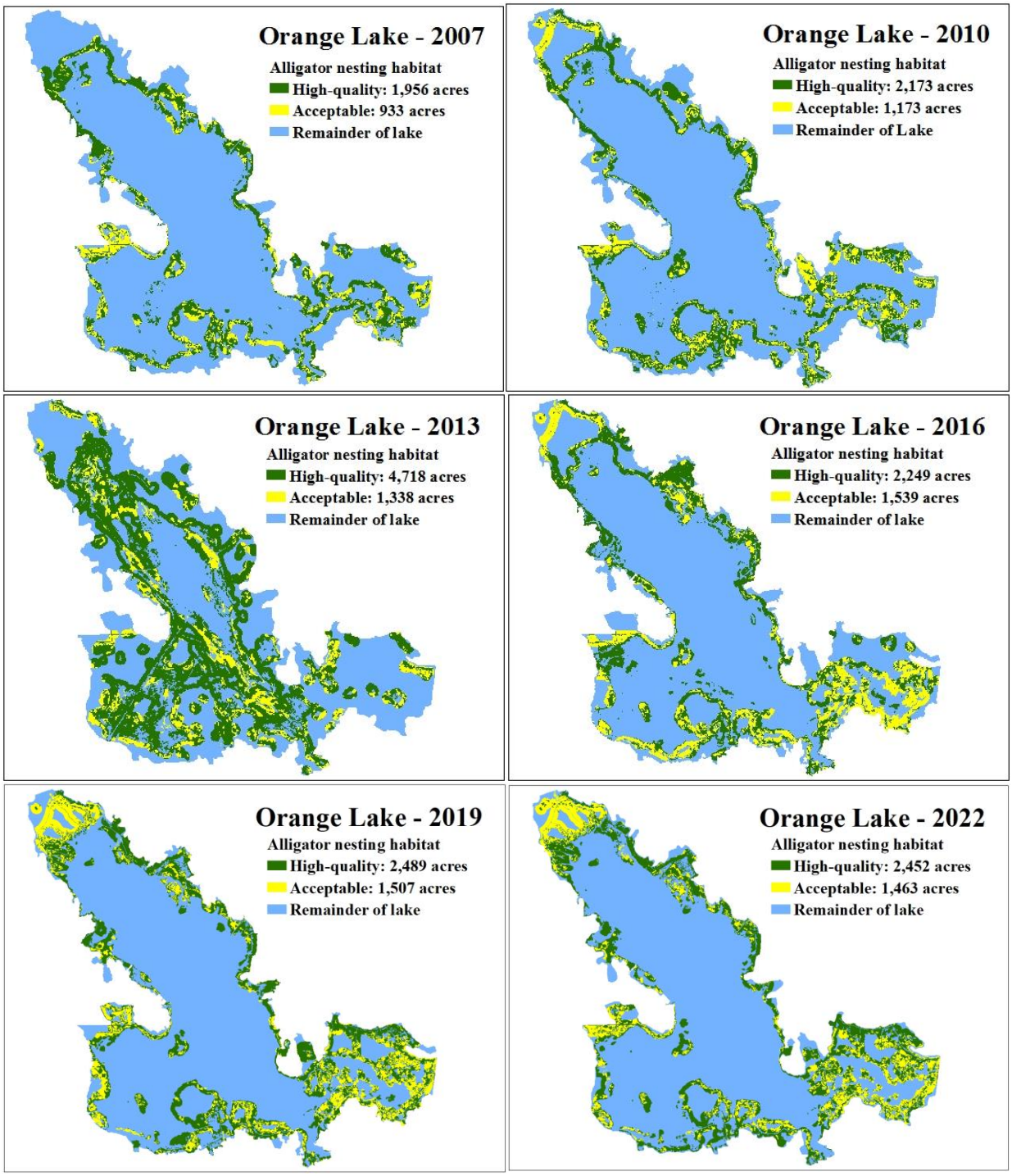

Figure D 3. Location of alligator nesting habitat identified with GIS analysis of vegetation maps on Orange Lake from 2007 to 2022.

Table D 4. Area (acres) of high-quality and acceptable habitat per habitat type for herpetofauna in Orange Lake, based on GIS analysis of vegetation maps produced from 2007 to 2022.

Orange Lake	Herpetofauna					
Habitat type	**2007**	**2010**	**2013**	**2016**	**2019**	**2022**
High-quality habitat						
Open water	132	222	307	387	334	199
Hardwood swamp	146	238	186	193	143	204
Tree island	86	119	114	101	190	191
Willow shrub swamp	693	888	320	412	618	341
Complex floating marsh	436	714	4,235	515	329	330
Tall linear-leaved shallow marsh	97	35	21	15	24	23
Maidencane shallow marsh	366	215	339	344	150	91
Mixed shrub swamp	397	557	794	681	608	835
Flag shallow marsh	59	18	45	47	113	154
Grass deep marsh		<1				
Low floating marsh	280	276	1,937	420	218	203
Mixed shallow marsh	1,590	1,679	1,405	1,114	1,570	1,665
Floating island	86	112	48	139	88	73
Floating-leaved deep marsh	147	362	497	46	115	262
Submersed aquatic vegetation	500	173	19	463	476	571
Sub-total high-quality habitat	**5,017**	**5,608**	**10,268**	**4,876**	**4,975**	**5,142**
Acceptable habitat						
Open water	511	790	15	538	461	519
Hardwood swamp	252	288	312	261	82	61
Tree island	56	43	89	71	52	47
Willow shrub swamp	519	425	508	628	468	370
Complex floating marsh	<1		42			
Tall linear-leaved shallow marsh	21	3	9	4	12	5
Maidencane shallow marsh	238	177	291	189	31	12
Mixed shrub swamp	273	140	475	502	119	158
Flag shallow marsh	16	3	40	35	68	53
Grass deep marsh		1				
Low floating marsh						
Mixed shallow marsh						
Floating island	<1	<1	3	2	<1	<1
Floating-leaved deep marsh	349	1,140	157	40	84	257
Submersed aquatic vegetation	2,387	3,615	<1	2,089	1,411	3,401
Sub-total acceptable habitat	**4,624**	**6,625**	**1,941**	**4,359**	**2,787**	**4,885**
Total habitat	**9,641**	**12,233**	**12,209**	**9,235**	**7,762**	**10,026**

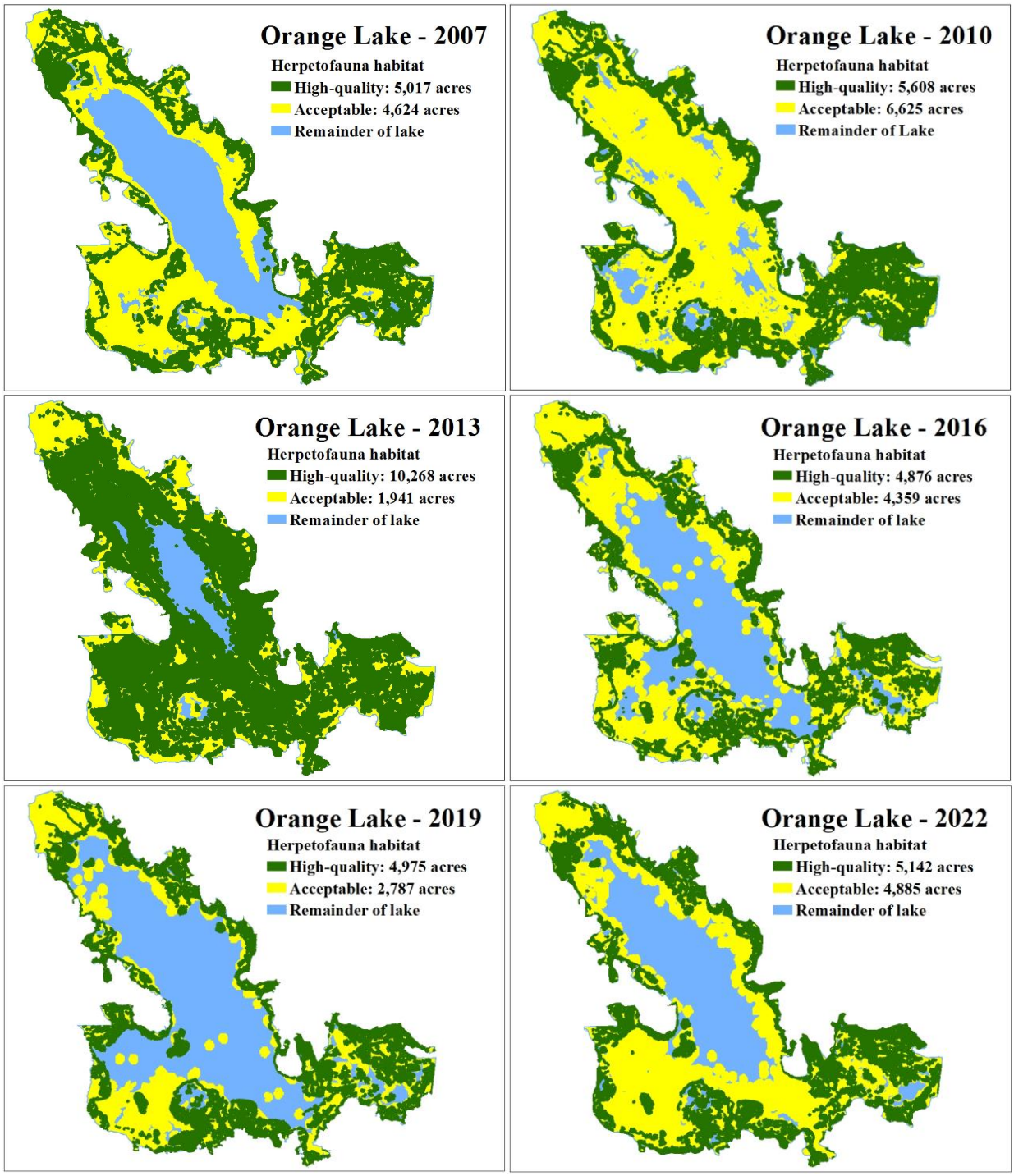

Figure D 4. Location of herpetofauna habitat identified with GIS analysis of vegetation maps on Orange Lake from 2007 to 2022.

Table D 5. Area (acres) of high-quality and acceptable habitat per habitat type for round-tailed muskrat in Orange Lake, based on GIS analysis of vegetation maps produced from 2007 to 2022.

Orange Lake	Round-tailed muskrat					
Habitat type	**2007**	**2010**	**2013**	**2016**	**2019**	**2022**
High-quality habitat						
Open water						
Hardwood swamp						
Tree island						
Willow shrub swamp						
Complex floating marsh						
Tall linear-leaved shallow marsh	54	3	13	10	12	9
Maidencane shallow marsh	618	399	637	550	190	106
Mixed shrub swamp						
Flag shallow marsh	24	4	3	26	30	36
Grass deep marsh						
Low floating marsh	117	66	142	141	74	34
Mixed shallow marsh	637	514	595	520	379	276
Floating island						
Floating-leaved deep marsh	36	66	22	13	12	15
Submersed aquatic vegetation						
Sub-total high-quality habitat	**1,485**	**1,053**	**1,413**	**1,260**	**696**	**476**
Acceptable habitat						
Open water						
Hardwood swamp						
Tree island						
Willow shrub swamp						
Complex floating marsh	378	665	2,372	502	304	312
Tall linear-leaved shallow marsh	64	34	17	9	24	20
Maidencane shallow marsh	1	1	1	2	2	2
Mixed shrub swamp						
Flag shallow marsh	55	17	83	57	153	174
Grass deep marsh		<1				
Low floating marsh	163	209	1,795	280	144	169
Mixed shallow marsh	953	1,155	810	589	1,188	1,373
Floating island	61	102	25	33	43	47
Floating-leaved deep marsh	222	799	617	17	127	331
Submersed aquatic vegetation						
Sub-total acceptable habitat	**1,899**	**2,982**	**5,721**	**1,490**	**1,985**	**2,427**
Total habitat	**3,384**	**4,035**	**7,134**	**2,750**	**2,681**	**2,902**

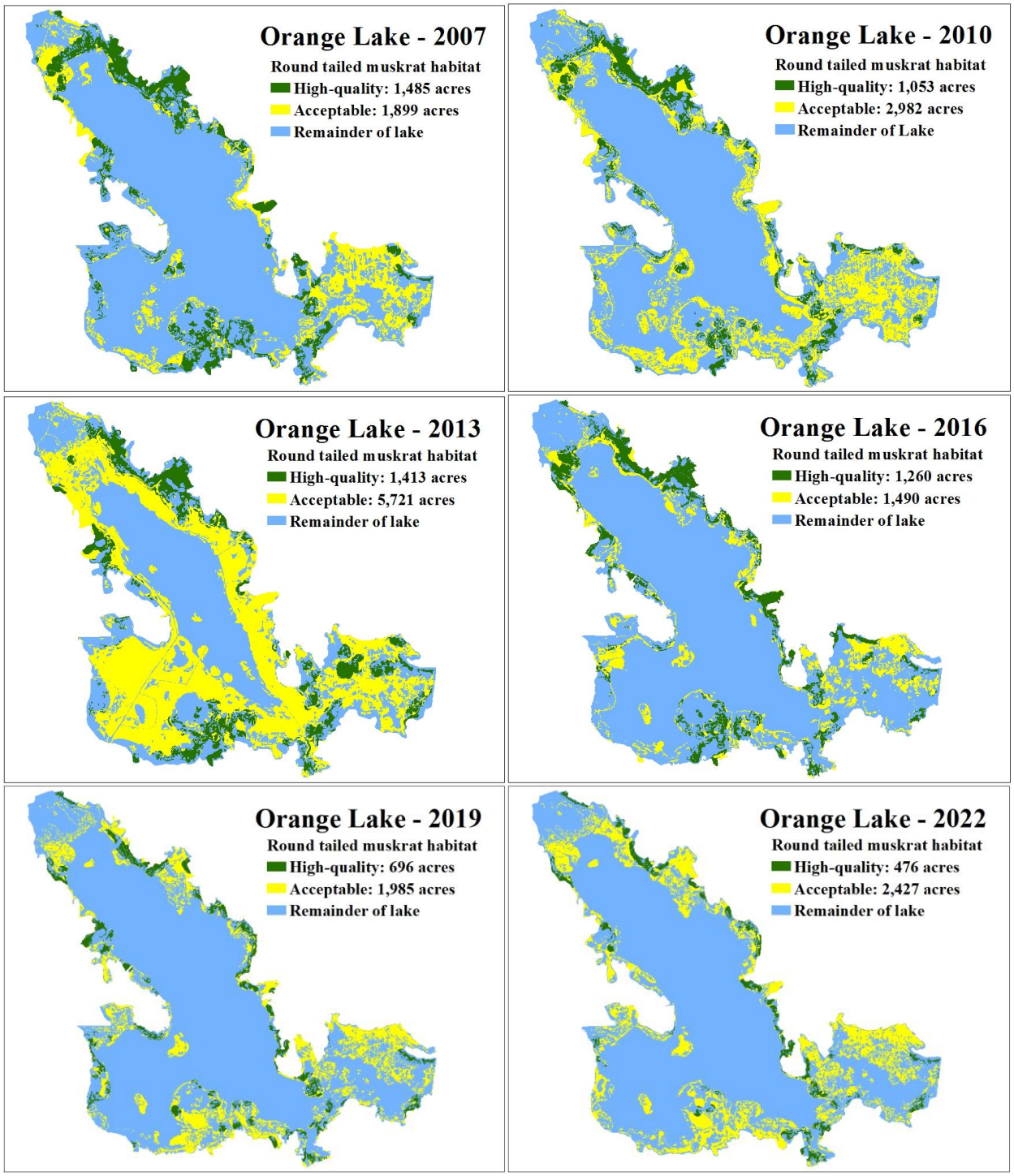

Figure D 5. Location of round-tailed muskrat habitat identified with GIS analysis of vegetation maps on Orange Lake from 2007 to 2022.

Table D 6. Area (acres) of high-quality and acceptable habitat per habitat type for wading bird foraging in Orange Lake, based on GIS analysis of vegetation maps produced from 2007 to 2022.

Orange Lake	Wading bird foraging					
Habitat type	**2007**	**2010**	**2013**	**2016**	**2019**	**2022**
High-quality habitat						
Open water						
Hardwood swamp						
Tree island						
Willow shrub swamp						
Complex floating marsh						
Tall linear-leaved shallow marsh	<1					
Maidencane shallow marsh						
Mixed shrub swamp						
Flag shallow marsh						<1
Grass deep marsh						
Low floating marsh						
Mixed shallow marsh	1	41	<1	19	45	26
Floating island	1	4	7	2	<1	5
Floating-leaved deep marsh						
Submersed aquatic vegetation						
Sub-total high-quality habitat	**2**	**45**	**7**	**21**	**45**	**31**
Acceptable habitat						
Open water	712	881	602	1,158	1,375	635
Hardwood swamp	107	167	25	212	156	161
Tree island	75	80	17	97	168	169
Willow shrub swamp	377	389	55	438	702	444
Complex floating marsh	35	27	554			<1
Tall linear-leaved shallow marsh	24	13		9	31	24
Maidencane shallow marsh		9				
Mixed shrub swamp	301	308	205	813	549	749
Flag shallow marsh	24	9	1	30	122	144
Grass deep marsh		2				
Low floating marsh	263	264	1,170	353	203	189
Mixed shallow marsh	604	550	89	545	1,150	1,158
Floating island	85	108	44	139	88	68
Floating-leaved deep marsh	366	1,016	606	29	108	210
Submersed aquatic vegetation	2,106	1,487	19	1,263	1,272	2,410
Sub-total acceptable habitat	**5,081**	**5,308**	**3,386**	**5,086**	**5,922**	**6,362**
Total habitat	**5,083**	**5,354**	**3,393**	**5,107**	**5,968**	**6,393**

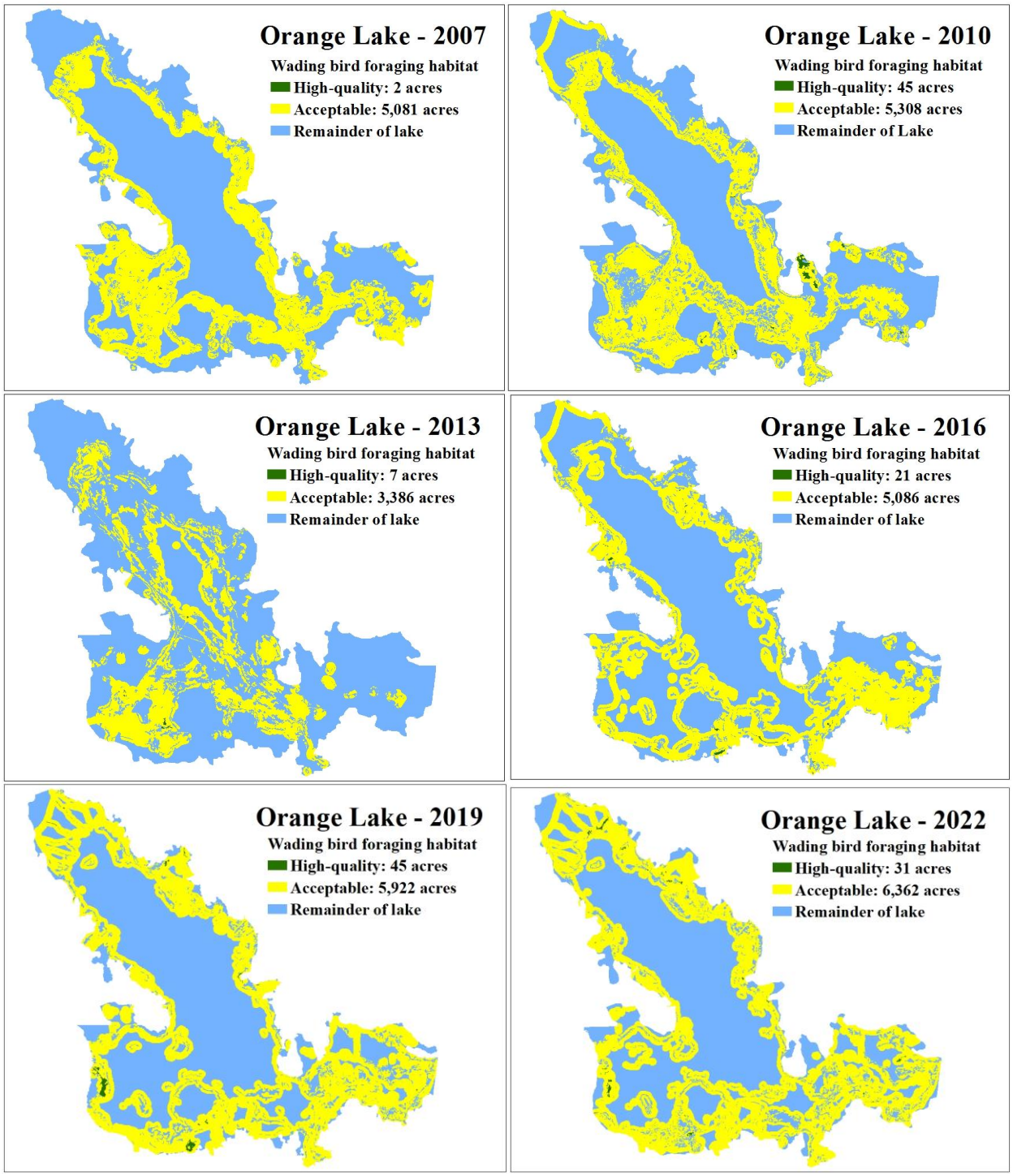

Figure D 6. Location of wading bird foraging habitat identified with GIS analysis of vegetation maps on Orange Lake from 2007 to 2022.

Table D 7. Area (acres) of high-quality and acceptable habitat per habitat type for wading bird roosting in Orange Lake, based on GIS analysis of vegetation maps produced from 2007 to 2022.

Orange Lake	Wading bird roosting					
Habitat type	**2007**	**2010**	**2013**	**2016**	**2019**	**2022**
High-quality habitat						
Open water						
Hardwood swamp						
Tree island	200	278	291	322	346	308
Willow shrub swamp	1,239	1,330	839	1,054	1,095	716
Complex floating marsh	7	14	186	2	1	1
Tall linear-leaved shallow marsh	<1		<1			
Maidencane shallow marsh						
Mixed shrub swamp	19	10	58	24	4	1
Flag shallow marsh						
Grass deep marsh						
Low floating marsh						
Mixed shallow marsh						
Floating island						
Floating-leaved deep marsh						
Submersed aquatic vegetation						
Sub-total high-quality habitat	**1,466**	**1,633**	**1,374**	**1,402**	**1,446**	**1,026**
Acceptable habitat						
Open water						
Hardwood swamp	407	549	567	433	226	280
Tree island						
Willow shrub swamp						
Complex floating marsh	392	671	3,205	514	328	329
Tall linear-leaved shallow marsh	118	37	30	19	36	29
Maidencane shallow marsh						
Mixed shrub swamp	692	705	1,242	1,221	749	1,007
Flag shallow marsh						
Grass deep marsh						
Low floating marsh						
Mixed shallow marsh						
Floating island						
Floating-leaved deep marsh						
Submersed aquatic vegetation						
Sub-total acceptable habitat	**1,609**	**1,962**	**5,043**	**2,186**	**1,339**	**1,646**
Total habitat	**3,075**	**3,595**	**6,418**	**3,588**	**2,785**	**2,672**

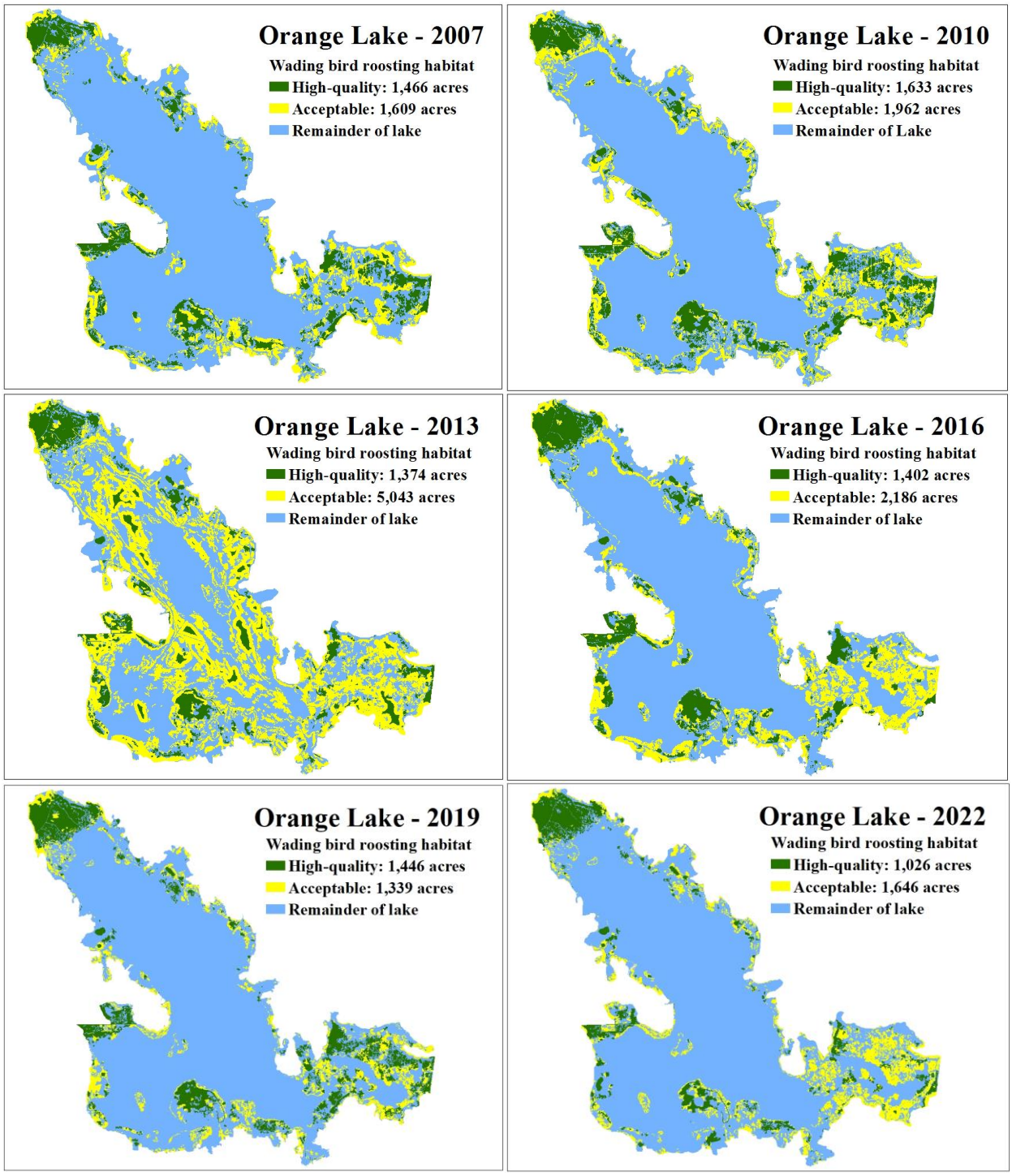

Figure D 7. Location of wading bird roosting habitat identified with GIS analysis of vegetation maps on Orange Lake from 2007 to 2022.

Table D 8. Area (acres) of high-quality and acceptable habitat per habitat type for ring-necked duck in Orange Lake, based on GIS analysis of vegetation maps produced from 2007 to 2022.

Orange Lake	Ring-necked duck					
Habitat type	**2007**	**2010**	**2013**	**2016**	**2019**	**2022**
High-quality habitat						
Open water	1,151	1,253	2	1,307	1,460	1,019
Hardwood swamp						
Tree island						
Willow shrub swamp						
Complex floating marsh						
Tall linear-leaved shallow marsh						
Maidencane shallow marsh						
Mixed shrub swamp						
Flag shallow marsh						
Grass deep marsh						
Low floating marsh						
Mixed shallow marsh				<1	2	5
Floating island						
Floating-leaved deep marsh	365	1,353	149	61	119	257
Submersed aquatic vegetation	2,356	3,613	<1	2,066	1,339	3,340
Sub-total high-quality habitat	**3,872**	**6,219**	**151**	**3,434**	**2,920**	**4,620**
Acceptable habitat						
Open water	657	311	56	1,306	1,459	809
Hardwood swamp						
Tree island						
Willow shrub swamp						
Complex floating marsh						
Tall linear-leaved shallow marsh	<1					
Maidencane shallow marsh		<1				
Mixed shrub swamp						
Flag shallow marsh						<1
Grass deep marsh		1				
Low floating marsh						
Mixed shallow marsh	179	157	7	259	588	573
Floating island						
Floating-leaved deep marsh	163	384	507	76	131	292
Submersed aquatic vegetation	533	176	19	487	554	635
Sub-total acceptable habitat	**1,532**	**1,031**	**590**	**2,127**	**2,732**	**2,309**
Total habitat	**5,404**	**7,249**	**741**	**5,561**	**5,651**	**6,929**

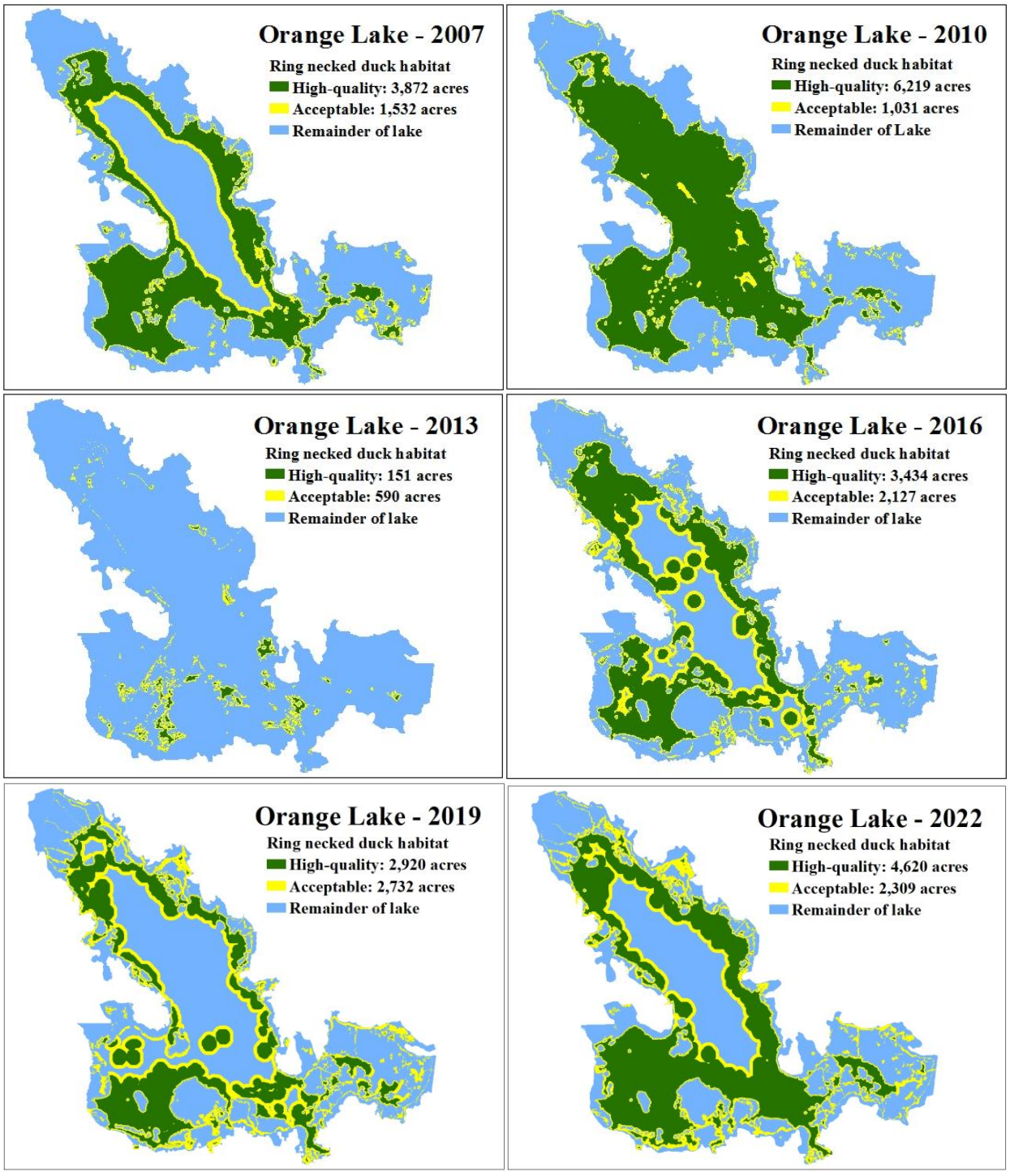

Figure D 8. Location of ring-necked duck habitat identified with GIS analysis of vegetation maps on Orange Lake from 2007 to 2022.

Table D 9. Area (acres) of high-quality and acceptable habitat per habitat type for wood duck in Orange Lake, based on GIS analysis of vegetation maps produced from 2007 to 2022.

Orange Lake	Wood duck					
Habitat type	**2007**	**2010**	**2013**	**2016**	**2019**	**2022**
High-quality habitat						
Open water	271	694	310	473	414	298
Hardwood swamp	11	21	3	39	41	35
Tree island						
Willow shrub swamp	82	77	3	121	221	163
Complex floating marsh						
Tall linear-leaved shallow marsh	<1					
Maidencane shallow marsh		9				
Mixed shrub swamp	87	73	12	317	229	288
Flag shallow marsh	3	3		8	44	43
Grass deep marsh						
Low floating marsh						
Mixed shallow marsh	168	156	5	251	516	503
Floating island						
Floating-leaved deep marsh	450	1,282	190	30	98	408
Submersed aquatic vegetation	1,121	823	19	482	625	1,035
Sub-total high-quality habitat	**2,192**	**3,137**	**542**	**1,721**	**2,188**	**2,773**
Acceptable habitat						
Open water	184	62	152	260	271	147
Hardwood swamp	28	46	5	70	52	48
Tree island						
Willow shrub swamp	102	105	5	148	205	138
Complex floating marsh	35	24	139			<1
Tall linear-leaved shallow marsh						
Maidencane shallow marsh	35	22	1	90	55	41
Mixed shrub swamp	83	86	25	249	148	213
Flag shallow marsh	7	2	<1	10	37	41
Grass deep marsh		2				
Low floating marsh						
Mixed shallow marsh	187	146	10	138	301	306
Floating island	1	4	8	3	<1	6
Floating-leaved deep marsh	28	178	81	28	25	51
Submersed aquatic vegetation	529	268	<1	346	308	489
Sub-total acceptable habitat	**1,218**	**945**	**425**	**1,342**	**1,402**	**1,479**
Total habitat	**3,411**	**4,082**	**968**	**3,063**	**3,590**	**4,251**

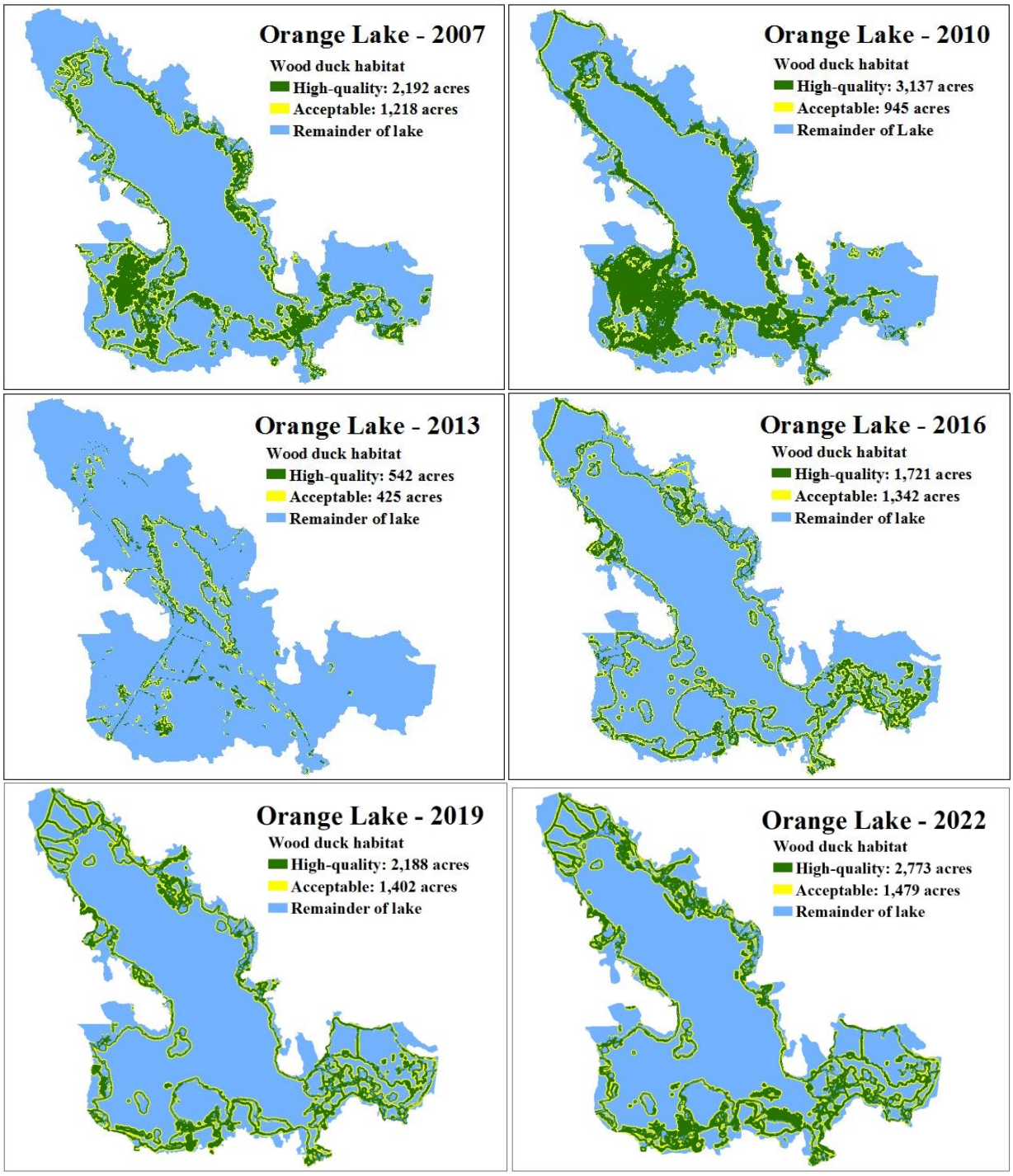

Figure D 9. Location of wood duck habitat identified with GIS analysis of vegetation maps on Orange Lake from 2007 to 2022

Table D 10. Area (acres) of high-quality and acceptable habitat per habitat type for black crappie in Orange Lake, based on GIS analysis of vegetation maps produced from 2007 to 2022.

Orange Lake	Black crappie					
Habitat type	**2007**	**2010**	**2013**	**2016**	**2019**	**2022**
High-quality habitat						
Open water	4,054	1,569	1,136	4,480	5,999	3,851
Hardwood swamp						
Tree island						
Willow shrub swamp						
Complex floating marsh						
Tall linear-leaved shallow marsh						
Maidencane shallow marsh						
Mixed shrub swamp						
Flag shallow marsh						
Grass deep marsh		1				
Low floating marsh						
Mixed shallow marsh						
Floating island						
Floating-leaved deep marsh	35	181	6	107	94	105
Submersed aquatic vegetation						
Sub-total high-quality habitat	**4,089**	**1,752**	**1,142**	**4,587**	**6,093**	**3,956**
Acceptable habitat						
Open water						
Hardwood swamp	11	21	3	39	42	40
Tree island	19	15	3	24	50	55
Willow shrub swamp	108	96	7	124	243	167
Complex floating marsh	197	280	1,992	262	186	204
Tall linear-leaved shallow marsh	<1					
Maidencane shallow marsh	37	33	1	93	58	41
Mixed shrub swamp	96	95	40	322	249	314
Flag shallow marsh	5	3		8	45	49
Grass deep marsh		<1				
Low floating marsh	208	225	599	246	161	138
Mixed shallow marsh	193	171	9	259	589	579
Floating island	83	98	51	121	72	63
Floating-leaved deep marsh	494	1,556	651	30	156	443
Submersed aquatic vegetation	2,889	3,789	19	2,553	1,893	3,976
Sub-total acceptable habitat	**4,340**	**6,382**	**3,375**	**4,080**	**3,744**	**6,068**
Total habitat	**8,429**	**8,134**	**4,517**	**8,667**	**9,837**	**10,023**

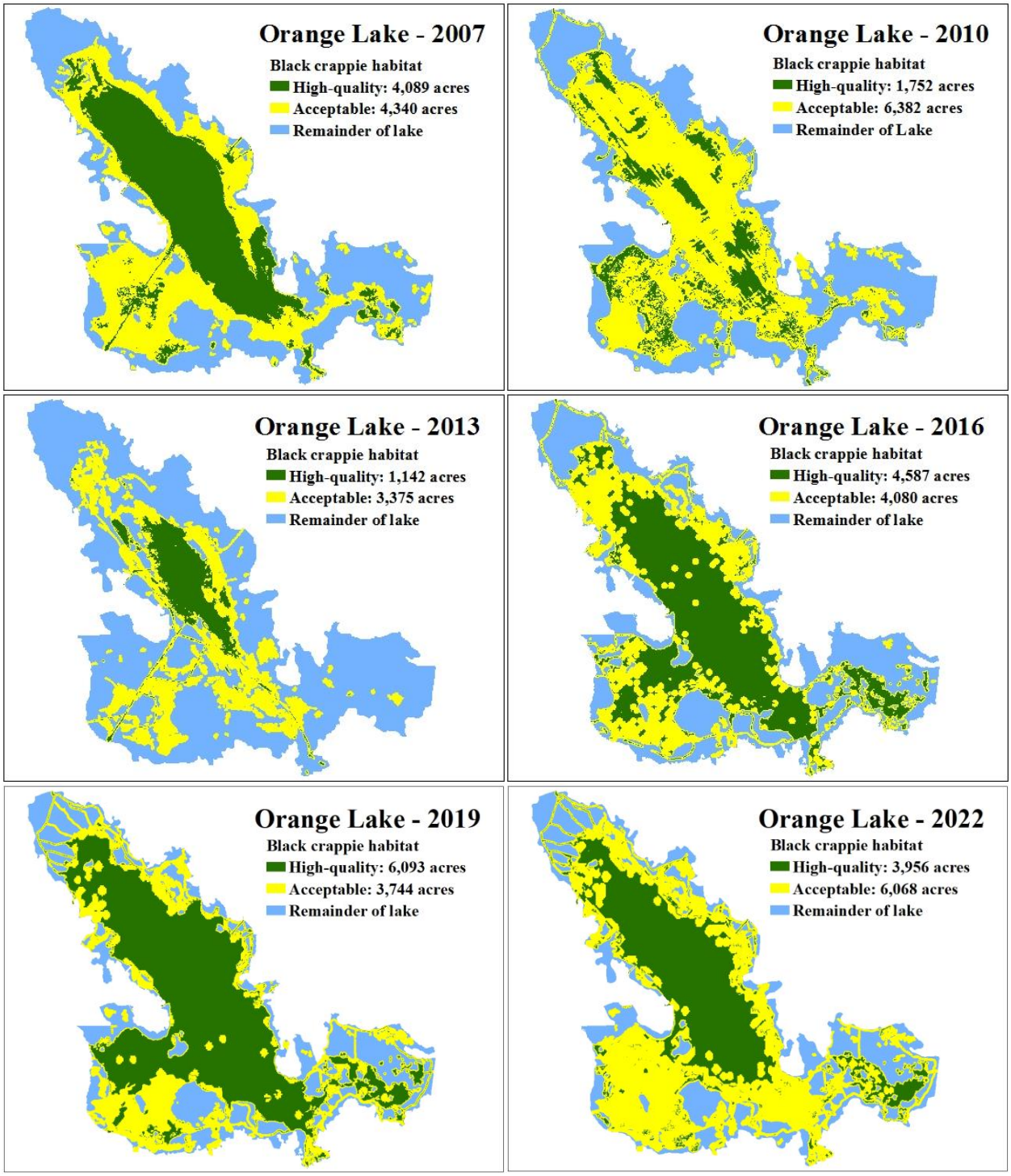

Figure D 10. Location of black crappie habitat identified with GIS analysis of vegetation maps on Orange Lake from 2007 to 2022.

Table D 11. Area (acres) of high-quality and acceptable habitat per habitat type for largemouth bass in Orange Lake, based on GIS analysis of vegetation maps produced from 2007 to 2022.

Orange Lake	Largemouth bass					
Habitat type	**2007**	**2010**	**2013**	**2016**	**2019**	**2022**
High-quality habitat						
Open water	578	794	<1	543	510	554
Hardwood swamp						
Tree island						
Willow shrub swamp						
Complex floating marsh						
Tall linear-leaved shallow marsh	<1					
Maidencane shallow marsh						
Mixed shrub swamp						
Flag shallow marsh						
Grass deep marsh		1				
Low floating marsh						
Mixed shallow marsh						
Floating island						
Floating-leaved deep marsh	420	988	78	54	118	439
Submersed aquatic vegetation	1,234	1,450	3	705	736	1,489
Sub-total high-quality habitat	**2,231**	**3,233**	**81**	**1,302**	**1,364**	**2,482**
Acceptable habitat						
Open water	419	550	322	779	748	452
Hardwood swamp						
Tree island	18	14	3	20	48	52
Willow shrub swamp	101	76	7	121	225	163
Complex floating marsh	178	244	755	257	185	203
Tall linear-leaved shallow marsh						
Maidencane shallow marsh		<1				
Mixed shrub swamp	93	78	34	298	235	304
Flag shallow marsh						<1
Grass deep marsh		<1				
Low floating marsh	196	223	409	240	158	125
Mixed shallow marsh	<1	1		4	9	7
Floating island	82	98	51	121	72	63
Floating-leaved deep marsh	109	748	579	83	133	109
Submersed aquatic vegetation	1,655	2,340	16	1,847	1,149	2,487
Sub-total acceptable habitat	**2,851**	**4,371**	**2,176**	**3,770**	**2,962**	**3,965**
Total habitat	**5,082**	**7,605**	**2,256**	**5,072**	**4,327**	**6,447**

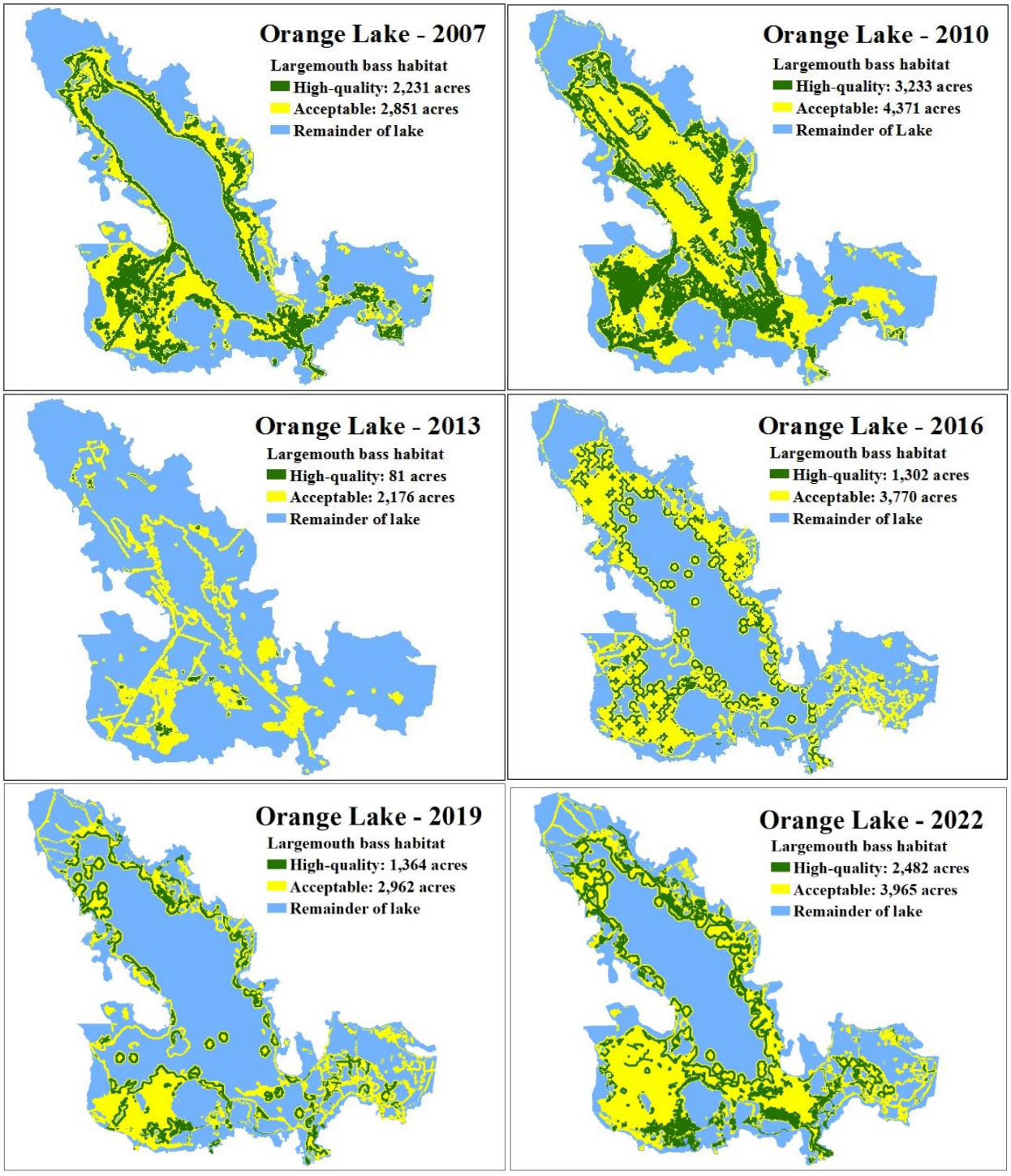

Figure D 11. Location of largemouth bass habitat identified with GIS analysis of vegetation maps on Orange Lake from 2007 to 2022.

Table D 12. Mean percentage (weighted by area) of high-quality (high) and acceptable (acc) habitat selected for each focal taxon that was also selected as usable habitat for the other focal taxa on Orange Lake in 2022. Data are presented in columns (i.e., 19% of high-quality alligator foraging habitat was also selected as high-quality herpetofauna habitat, and 18% of high-quality herpetofauna habitat was also selected as high-quality alligator foraging habitat, etc.). Bold cells indicate that half or more of the habitat was also selected by the corresponding focal taxon [i.e., 86% of high-quality alligator foraging habitat was selected as high-quality (19%) or acceptable (67%) habitat for herpetofauna].

Focal taxa		Alligator foraging		Alligator nesting		Herpetofauna		Wading bird foraging		Wading bird roosting	
	Habitat	High	Acc	High	Acc	High	Acc	High	Acc	High	Acc
Alligator foraging	High	**100%**	**0%**	1%	1%	18%	**67%**	**100%**	**48%**	0%	0%
	Acc	**0%**	**100%**	11%	5%	9%	**19%**	**0%**	**8%**	3%	7%
Alligator nesting	High	0%	7%	**100%**	**0%**	**45%**	2%	0%	28%	**22%**	**21%**
	Acc	0%	2%	**0%**	**100%**	**20%**	8%	47%	19%	**56%**	**53%**
Herpetofauna	High	**19%**	12%	**94%**	**71%**	**100%**	**0%**	**99%**	**56%**	**52%**	**82%**
	Acc	**67%**	24%	**4%**	**28%**	**0%**	**100%**	**1%**	**40%**	**41%**	**13%**
Wading bird foraging	High	**1%**	0%	**0%**	**1%**	**1%**	**0%**	**100%**	**0%**	**0%**	**0%**
	Acc	**63%**	13%	**71%**	**82%**	**69%**	**52%**	**0%**	**100%**	**60%**	**55%**
Wading bird roosting	High	0%	1%	9%	**40%**	10%	9%	0%	10%	**100%**	**0%**
	Acc	0%	3%	14%	**60%**	26%	4%	0%	14%	**0%**	**100%**
Round-tailed muskrat	High	0%	1%	**17%**	0%	**9%**	0%	0%	5%	0%	1%
	Acc	3%	10%	**73%**	1%	**44%**	3%	30%	23%	0%	20%
Wood duck	High	34%	8%	21%	**31%**	**36%**	18%	**73%**	**39%**	16%	19%
	Acc	14%	1%	16%	**24%**	**14%**	14%	**27%**	**22%**	13%	15%
Ring-necked duck	High	**76%**	23%	0%	0%	0%	**82%**	**15%**	**33%**	0%	0%
	Acc	**22%**	21%	23%	1%	31%	**3%**	**68%**	**26%**	0%	0%
Black crappie	High	**30%**	**64%**	0%	0%	**5%**	**12%**	**0%**	**10%**	0%	0%
	Acc	**70%**	**36%**	45%	34%	**45%**	**77%**	**100%**	**63%**	22%	33%
Largemouth bass	High	**48%**	3%	0%	0%	11%	**39%**	0%	**25%**	0%	0%
	Acc	**44%**	29%	18%	33%	24%	**49%**	39%	**35%**	21%	31%
Area (acres)		4,896	3,872	2,453	1,463	5,143	4,884	31	6,363	1,027	1,645
No. taxa $\leq$ 25% overlap		3	5	4	3	0	3	1	1	5	3
No. taxa 25-75% overlap		2	3	3	3	9	2	3	7	2	5
No. taxa $\geq$ 75% overlap		4	1	2	3	0	4	5	1	2	1

Table D 12. Continued.

Focal taxa		Round-tailed muskrat		Wood duck		Ring-necked duck		Black crappie		Largemouth bass	
	Habitat	High	Acc	High	Acc	High	Acc	High	Acc	High	Acc
Alligator foraging	High	0%	7%	**59%**	45%	**81%**	**47%**	**37%**	**57%**	**96%**	**54%**
	Acc	11%	17%	**11%**	3%	**19%**	**35%**	**63%**	**23%**	**4%**	**28%**
Alligator nesting	High	**86%**	**73%**	19%	**26%**	0%	24%	0%	18%	0%	11%
	Acc	**0%**	**0%**	17%	**24%**	0%	0%	0%	8%	0%	12%
Herpetofauna	High	**94%**	**93%**	**67%**	**47%**	**0%**	**69%**	6%	**38%**	**23%**	**32%**
	Acc	**5%**	**7%**	**32%**	**46%**	**87%**	**7%**	15%	**62%**	**76%**	**61%**
Wading bird foraging	High	**0%**	**0%**	**1%**	**1%**	0%	**1%**	0%	**1%**	**0%**	**0%**
	Acc	**61%**	**61%**	**89%**	**95%**	46%	**71%**	16%	**66%**	**65%**	**56%**
Wading bird roosting	High	0%	0%	6%	9%	0%	0%	0%	4%	0%	5%
	Acc	2%	14%	11%	17%	0%	0%	0%	9%	0%	13%
Round-tailed muskrat	High	**100%**	**0%**	5%	7%	0%	5%	0%	3%	1%	1%
	Acc	**0%**	**100%**	24%	21%	2%	30%	0%	19%	9%	11%
Wood duck	High	26%	27%	**100%**	**0%**	14%	**69%**	9%	**40%**	**51%**	23%
	Acc	23%	13%	**0%**	**100%**	14%	**3%**	4%	**10%**	**11%**	10%
Ring-necked duck	High	0%	4%	**23%**	43%	**100%**	**0%**	27%	**58%**	**74%**	**63%**
	Acc	25%	28%	**58%**	5%	**0%**	**100%**	21%	**24%**	**26%**	**14%**
Black crappie	High	0%	0%	**13%**	**11%**	**23%**	**37%**	**100%**	**0%**	**26%**	**12%**
	Acc	41%	48%	**87%**	**40%**	**77%**	**63%**	**0%**	**100%**	**74%**	**88%**
Largemouth bass	High	3%	10%	**45%**	18%	**40%**	**28%**	16%	**30%**	**100%**	**0%**
	Acc	6%	18%	**33%**	26%	**54%**	**23%**	12%	**58%**	**0%**	**100%**
Area (acres)		476	2,426	2,773	1,478	4,620	2,309	3,954	6,069	2,482	3,965
No. taxa $\leq$ 25% overlap		3	2	1	0	3	2	6	2	3	3
No. taxa 25-75% overlap		4	6	3	7	2	4	2	3	2	2
No. taxa $\geq$ 75% overlap		2	1	5	2	4	3	1	4	4	4

APPENDIX E: LOCHLOOSA LAKE HABITAT EVALUATIONS 2007-2022

Craig Mallison, FWRI Freshwater Plants Research

METHODS

Habitat conditions for fish and wildlife on Lochloosa Lake were evaluated using GIS analysis of vegetation maps created in each mapping year (Figure E 1). Methods were the same as those for Orange Lake (Appendix D).

RESULTS

Results for individual focal taxa analyses on Lochloosa Lake (2007, 2010, 2013, 2016, 2019, and 2022) are presented in Tables E 1-10 and Figures E 2-11. Results for combined analysis are presented in Figure 10 (not duplicated in Appendix E).

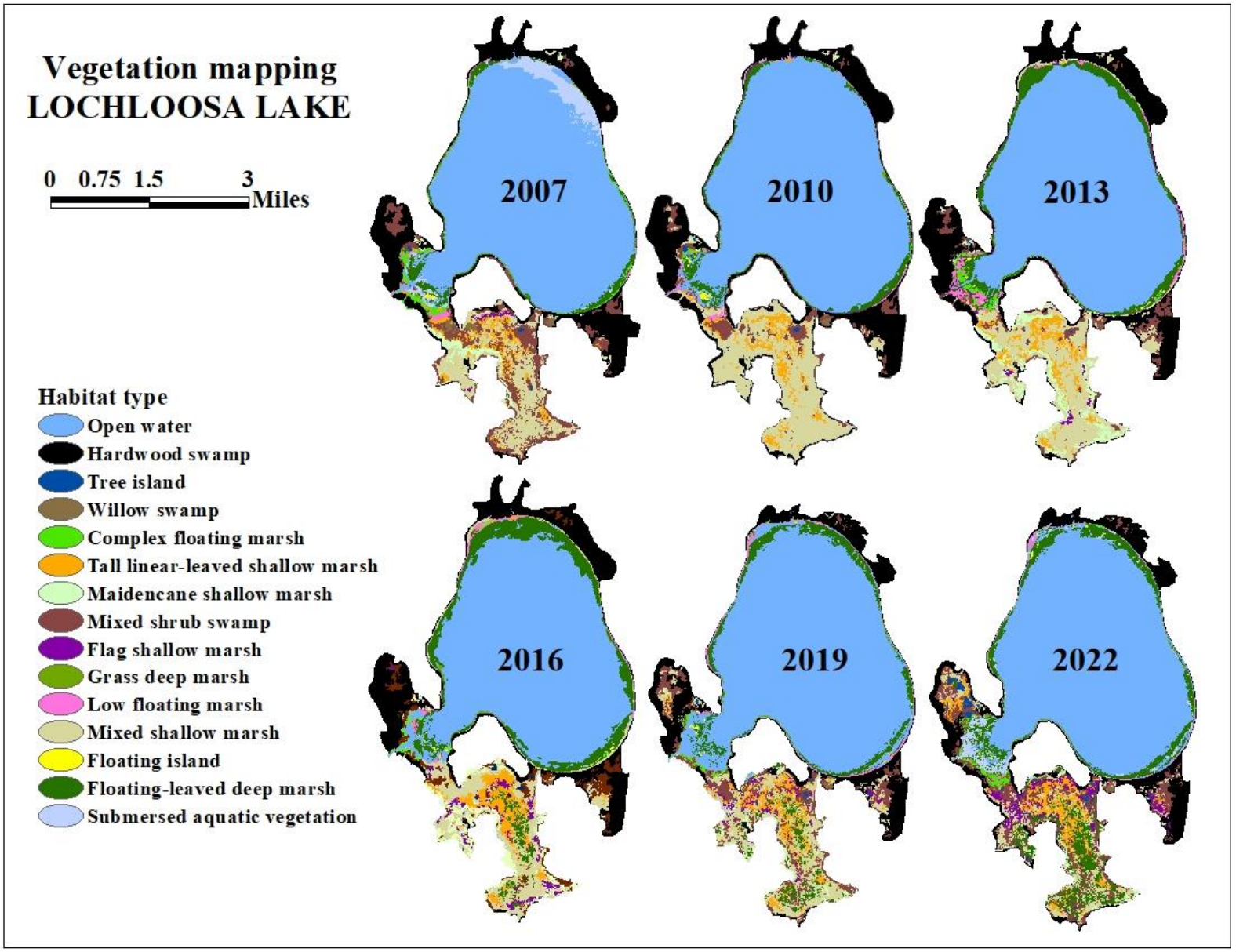

Figure E 1. Lochloosa Lake littoral vegetation maps from 2007 to 2022.

Table E 1. Area (acres) of high-quality and acceptable habitat per habitat type for alligator foraging in Lochloosa Lake, based on GIS analysis of vegetation maps produced from 2007 to 2022.

Lochloosa Lake	Alligator foraging					
Habitat type	**2007**	**2010**	**2013**	**2016**	**2019**	**2022**
High-quality habitat						
Open water	705	652	512	726	924	718
Hardwood swamp						
Tree island						
Willow shrub swamp						
Complex floating marsh	8		1			
Tall linear-leaved shallow marsh	<1					
Maidencane shallow marsh						
Mixed shrub swamp						
Flag shallow marsh		<1	2			
Grass deep marsh	24	28	3	24	26	16
Low floating marsh						
Mixed shallow marsh		<1	4		15	7
Floating island	3	4	4	9	8	7
Floating-leaved deep marsh	89	30	230	294	152	79
Submersed aquatic vegetation	241		12	<1	2	164
Sub-total high-quality habitat	**1,070**	**715**	**768**	**1,053**	**1,127**	**991**
Acceptable habitat						
Open water	4,441	4,715	4,475	4,090	4,329	4,322
Hardwood swamp	19	8	5	6	13	19
Tree island		<1	<1	<1	<1	<1
Willow shrub swamp			<1	<1	<1	<1
Complex floating marsh	10	1	10	5	4	6
Tall linear-leaved shallow marsh	1	2	1	32	31	48
Maidencane shallow marsh			2	21	6	8
Mixed shrub swamp	2	2	1	5	16	36
Flag shallow marsh		8	10	5	4	17
Grass deep marsh	19	3	15		6	13
Low floating marsh	5	12	21	13	19	13
Mixed shallow marsh		2	6	52	69	64
Floating island						
Floating-leaved deep marsh	141	254	263	545	416	762
Submersed aquatic vegetation	53					
Sub-total acceptable habitat	**4,690**	**5,005**	**4,809**	**4,775**	**4,916**	**5,310**
Total habitat	**5,760**	**5,720**	**5,577**	**5,828**	**6,043**	**6,300**

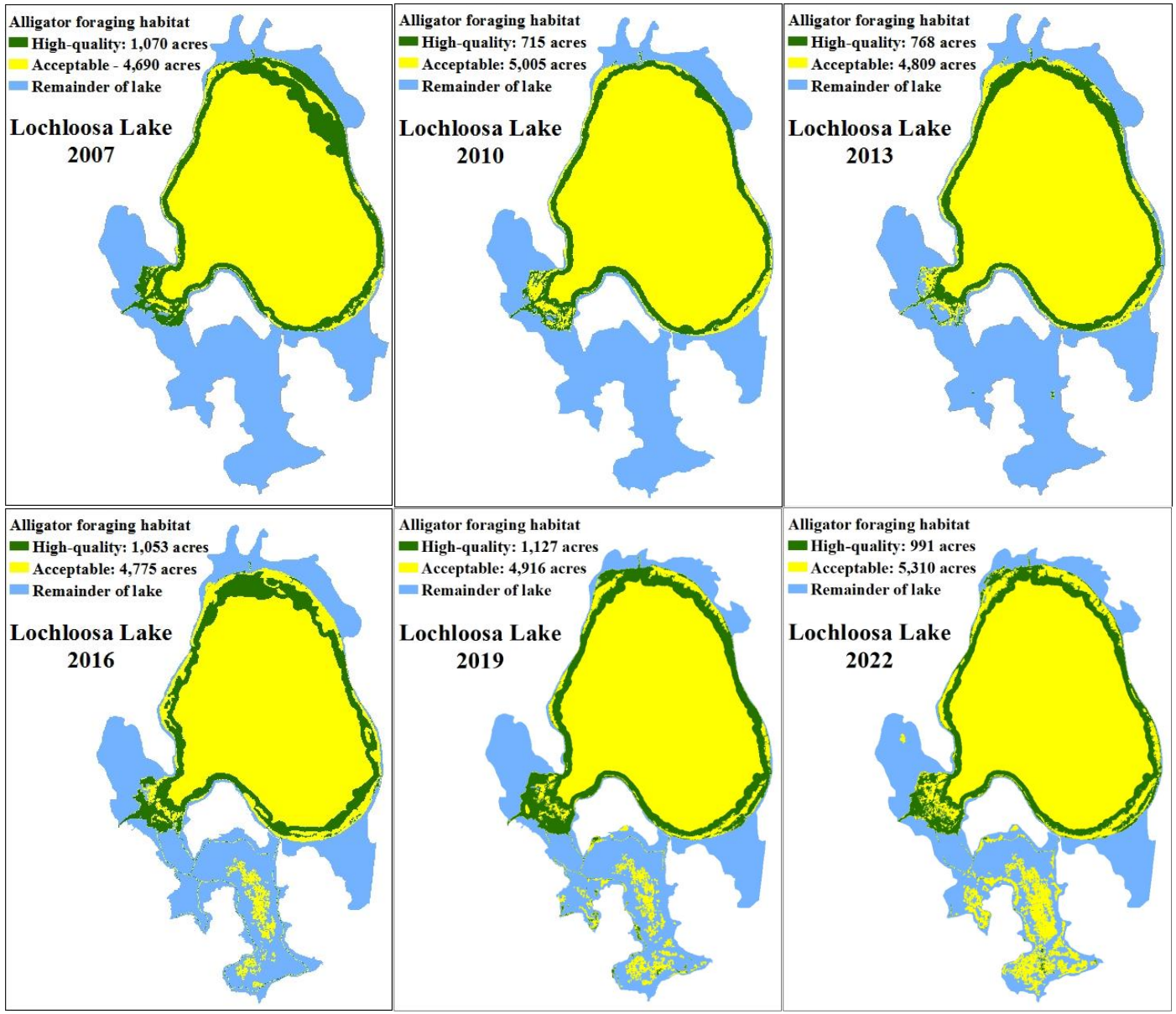

Figure E 2. Location of alligator foraging habitat identified with GIS analysis of vegetation maps on Lochloosa Lake from 2007 to 2022.

Table E 2. Area (acres) of high-quality and acceptable habitat per habitat type for alligator nesting in Lochloosa Lake, based on GIS analysis of vegetation maps produced from 2007 to 2022.

Lochloosa Lake	Alligator nesting					
Habitat type	**2007**	**2010**	**2013**	**2016**	**2019**	**2022**
High-quality habitat						
Open water						
Hardwood swamp						
Tree island	7	15	7	16	12	46
Willow shrub swamp						
Complex floating marsh	73	13	58	33	38	53
Tall linear-leaved shallow marsh	11	28	32	248	206	248
Maidencane shallow marsh	1	3	35	208	68	52
Mixed shrub swamp						
Flag shallow marsh		22	51	98	73	141
Grass deep marsh						
Low floating marsh	26	42	114	61	80	43
Mixed shallow marsh	23	144	162	606	568	365
Floating island	8	13	8	13	11	10
Floating-leaved deep marsh						
Submersed aquatic vegetation						
Sub-total high-quality habitat	**149**	**280**	**465**	**1,284**	**1,056**	**958**
Acceptable habitat						
Open water						
Hardwood swamp						
Tree island						
Willow shrub swamp	2	1	5	4	5	4
Complex floating marsh	4		1			
Tall linear-leaved shallow marsh						
Maidencane shallow marsh						
Mixed shrub swamp	81	84	55	186	302	400
Flag shallow marsh		<1	2			
Grass deep marsh						
Low floating marsh						
Mixed shallow marsh		<1	4		10	6
Floating island		<1			1	1
Floating-leaved deep marsh						
Submersed aquatic vegetation						
Sub-total acceptable habitat	**86**	**86**	**67**	**191**	**318**	**411**
Total habitat	**236**	**366**	**533**	**1,474**	**1,373**	**1,370**

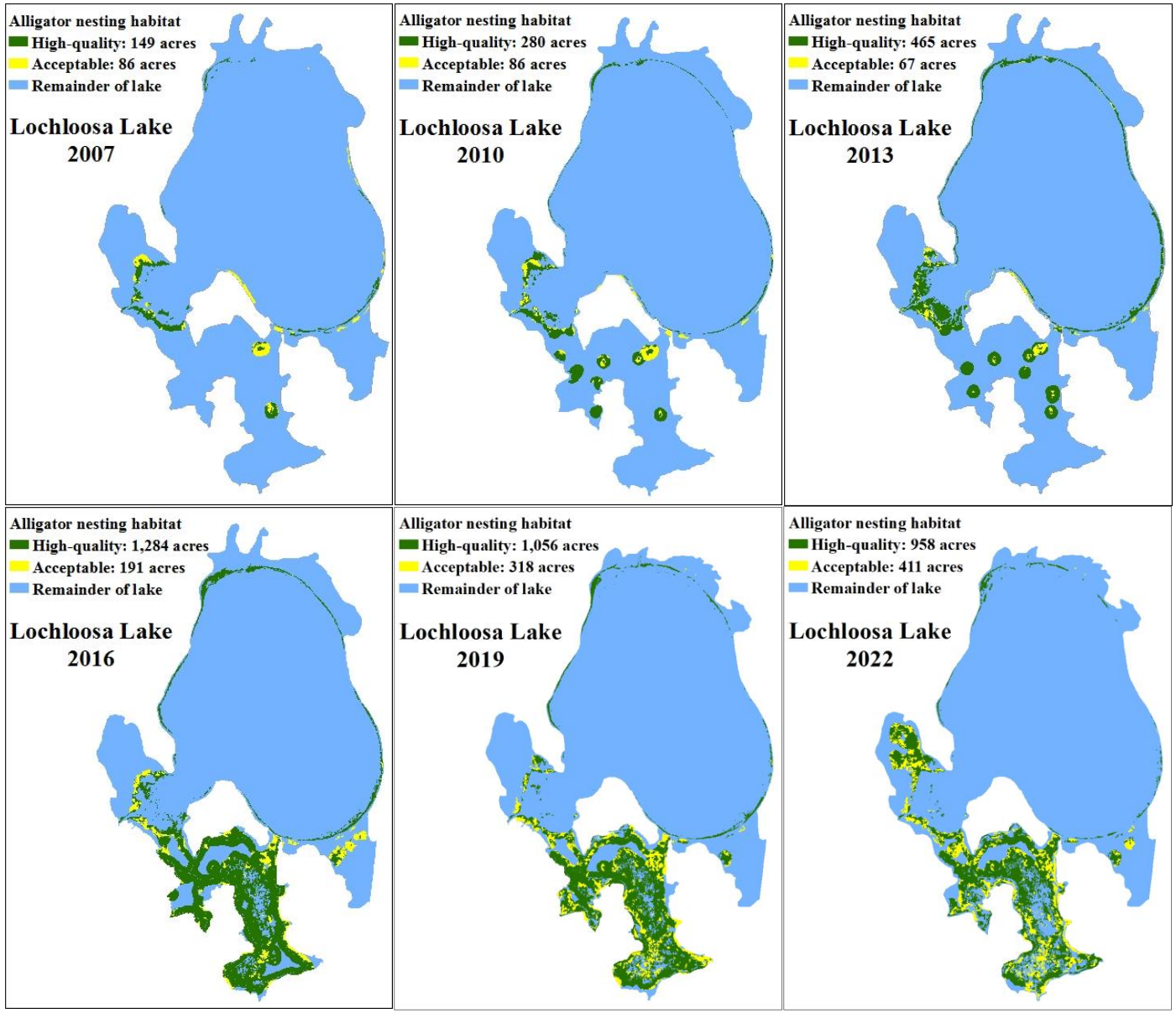

Figure E 3. Location of alligator nesting habitat identified with GIS analysis of vegetation maps on Lochloosa Lake from 2007 to 2022.

Table E 3. Area (acres) of high-quality and acceptable habitat per habitat type for herpetofauna in Lochloosa Lake, based on GIS analysis of vegetation maps produced from 2007 to 2022.

Lochloosa Lake	Herpetofauna					
Habitat type	**2007**	**2010**	**2013**	**2016**	**2019**	**2022**
High-quality habitat						
Open water	36	53	12	78	114	48
Hardwood swamp	115	230	194	161	207	178
Tree island	1	8	4	8	5	17
Willow shrub swamp	7	<1	6	6	8	7
Complex floating marsh	88	13	59	33	40	62
Tall linear-leaved shallow marsh	121	190	192	137	188	162
Maidencane shallow marsh	51	5	215	139	62	33
Mixed shrub swamp	284	122	107	140	319	309
Flag shallow marsh	16	10	46	75	63	82
Grass deep marsh	3	4	4	2	2	<1
Low floating marsh	42	50	114	61	80	43
Mixed shallow marsh	694	1,212	1,057	764	717	432
Floating island	8	14	8	13	11	11
Floating-leaved deep marsh	53	67	151	232	219	290
Submersed aquatic vegetation	20		8	<1	1	25
Sub-total high-quality habitat	**1,540**	**1,977**	**2,176**	**1,849**	**2,037**	**1,698**
Acceptable habitat						
Open water	242	209	68	130	191	251
Hardwood swamp	1,029	1,008	945	941	634	605
Tree island	5	5	2	7	6	23
Willow shrub swamp	33	9	2	2	4	3
Complex floating marsh	2					
Tall linear-leaved shallow marsh	56	20	37	160	61	133
Maidencane shallow marsh	65	<1	62	88	5	10
Mixed shrub swamp	358	142	137	162	181	224
Flag shallow marsh	6	12	21	43	24	88
Grass deep marsh	38	25	14	21	26	28
Low floating marsh						
Mixed shallow marsh						
Floating island						
Floating-leaved deep marsh	148	206	246	428	283	538
Submersed aquatic vegetation	273		4		<1	138
Sub-total acceptable habitat	**2,255**	**1,637**	**1,537**	**1,982**	**1,416**	**2,041**
Total habitat	**3,795**	**3,615**	**3,713**	**3,831**	**3,452**	**3,739**

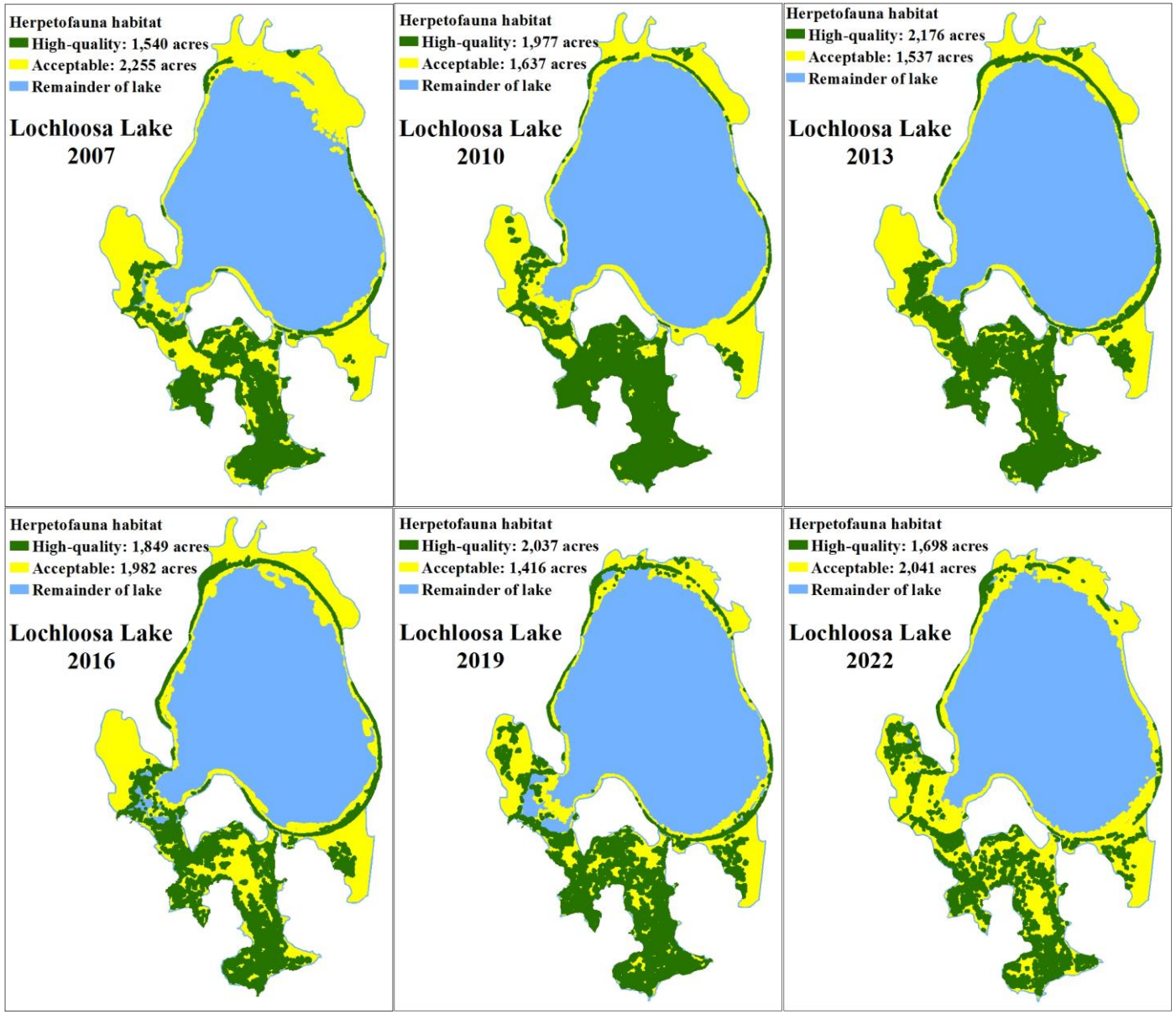

Figure E 4. Location of herpetofauna habitat identified with GIS analysis of vegetation maps on Lochloosa Lake from 2007 to 2022.

Table E 4. Area (acres) of high-quality and acceptable habitat per habitat type for round-tailed muskrat in Lochloosa Lake, based on GIS analysis of vegetation maps produced from 2007 to 2022.

Lochloosa Lake	Round-tailed muskrat					
Habitat type	**2007**	**2010**	**2013**	**2016**	**2019**	**2022**
High-quality habitat						
Open water						
Hardwood swamp						
Tree island						
Willow shrub swamp						
Complex floating marsh						
Tall linear-leaved shallow marsh	58	4	101	88	22	9
Maidencane shallow marsh	119	6	280	264	74	52
Mixed shrub swamp						
Flag shallow marsh	9	1	33	67	22	14
Grass deep marsh			4			
Low floating marsh	1	2	22	5	9	1
Mixed shallow marsh	168	25	494	304	236	87
Floating island						
Floating-leaved deep marsh	1	1	39	18	43	77
Submersed aquatic vegetation						
Sub-total high-quality habitat	**356**	**38**	**973**	**746**	**408**	**240**
Acceptable habitat						
Open water						
Hardwood swamp						
Tree island						
Willow shrub swamp						
Complex floating marsh	67	11	57	29	27	54
Tall linear-leaved shallow marsh	120	205	123	210	227	285
Maidencane shallow marsh	<1		<1	<1	<1	
Mixed shrub swamp						
Flag shallow marsh	14	16	21	50	64	158
Grass deep marsh	29	17	8	3	19	25
Low floating marsh	40	39	67	57	71	43
Mixed shallow marsh	526	1,028	516	460	476	345
Floating island	8	13	8	12	11	10
Floating-leaved deep marsh	145	167	203	471	384	580
Submersed aquatic vegetation						
Sub-total acceptable habitat	**950**	**1,496**	**1,003**	**1,292**	**1,278**	**1,500**
Total habitat	**1,305**	**1,534**	**1,976**	**2,037**	**1,686**	**1,740**

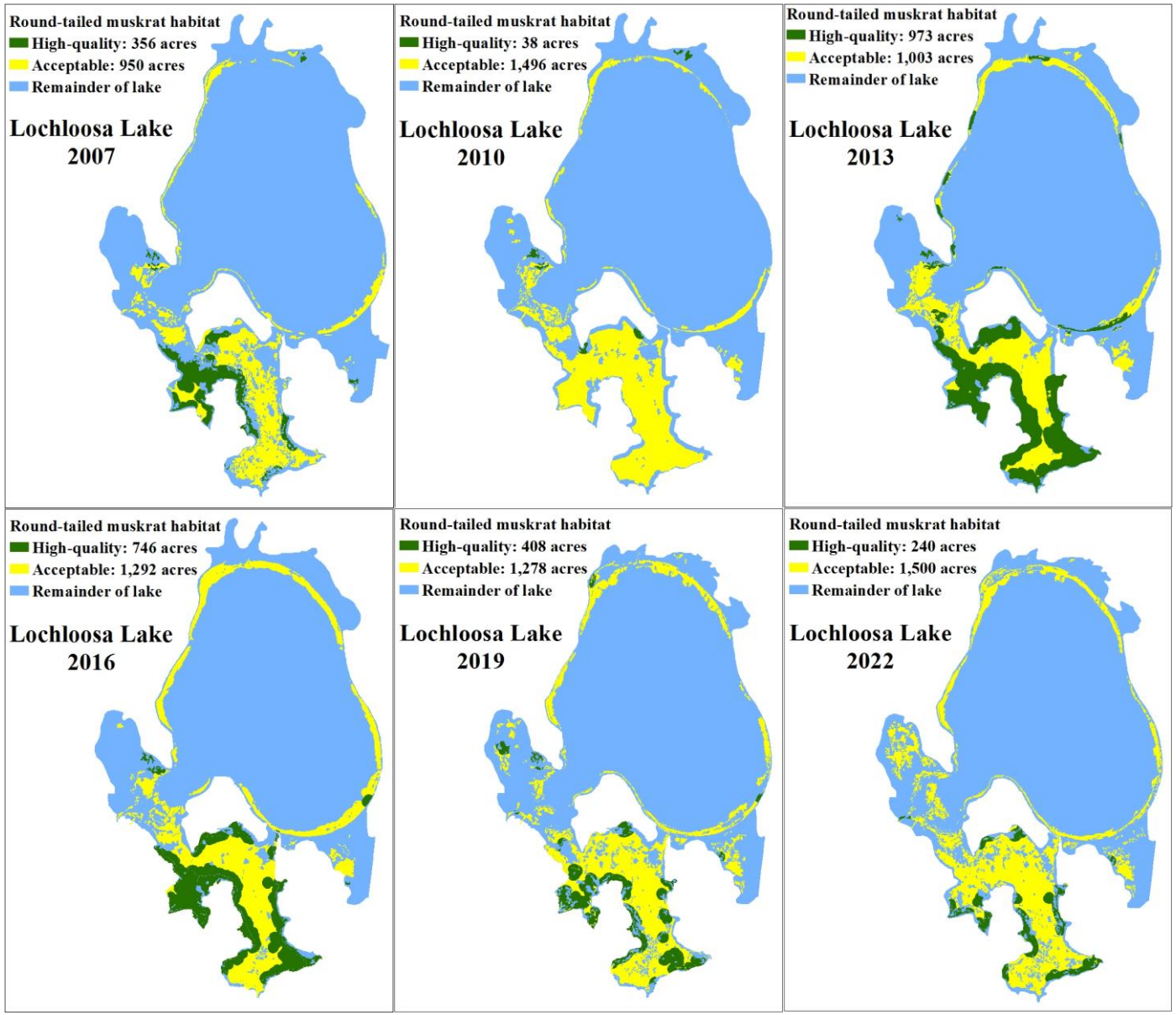

Figure E 5. Location of round-tailed muskrat habitat identified with GIS analysis of vegetation maps on Lochloosa Lake from 2007 to 2022.

Table E 5. Area (acres) of high-quality and acceptable habitat per habitat type for wading bird foraging in Lochloosa Lake, based on GIS analysis of vegetation maps produced from 2007 to 2022.

Lochloosa Lake	Wading bird foraging					
Habitat type	**2007**	**2010**	**2013**	**2016**	**2019**	**2022**
High-quality habitat						
Open water						
Hardwood swamp						
Tree island						
Willow shrub swamp						
Complex floating marsh						
Tall linear-leaved shallow marsh	<1					
Maidencane shallow marsh						
Mixed shrub swamp						
Flag shallow marsh		<1	2			
Grass deep marsh						
Low floating marsh						
Mixed shallow marsh		<1	4		15	7
Floating island		<1			1	1
Floating-leaved deep marsh						
Submersed aquatic vegetation						
Sub-total high-quality habitat	**<1**	**1**	**6**	**0**	**16**	**7**
Acceptable habitat						
Open water	537	652	512	726	924	710
Hardwood swamp	265	269	240	264	269	340
Tree island	2	3	1	6	4	18
Willow shrub swamp	2	1	5	4	5	4
Complex floating marsh	4		1			
Tall linear-leaved shallow marsh	10	13	8	215	182	191
Maidencane shallow marsh						
Mixed shrub swamp	35	34	22	115	244	291
Flag shallow marsh		22	50	84	59	117
Grass deep marsh	43	31	18	24	32	30
Low floating marsh	25	41	108	61	80	42
Mixed shallow marsh	2	30	76	516	513	308
Floating island	8	13	8	13	11	10
Floating-leaved deep marsh	141	254	263	545	416	762
Submersed aquatic vegetation	124		12	<1	2	164
Sub-total acceptable habitat	**1,196**	**1,363**	**1,323**	**2,574**	**2,742**	**2,987**
Total habitat	**1,196**	**1,364**	**1,329**	**2,574**	**2,757**	**2,994**

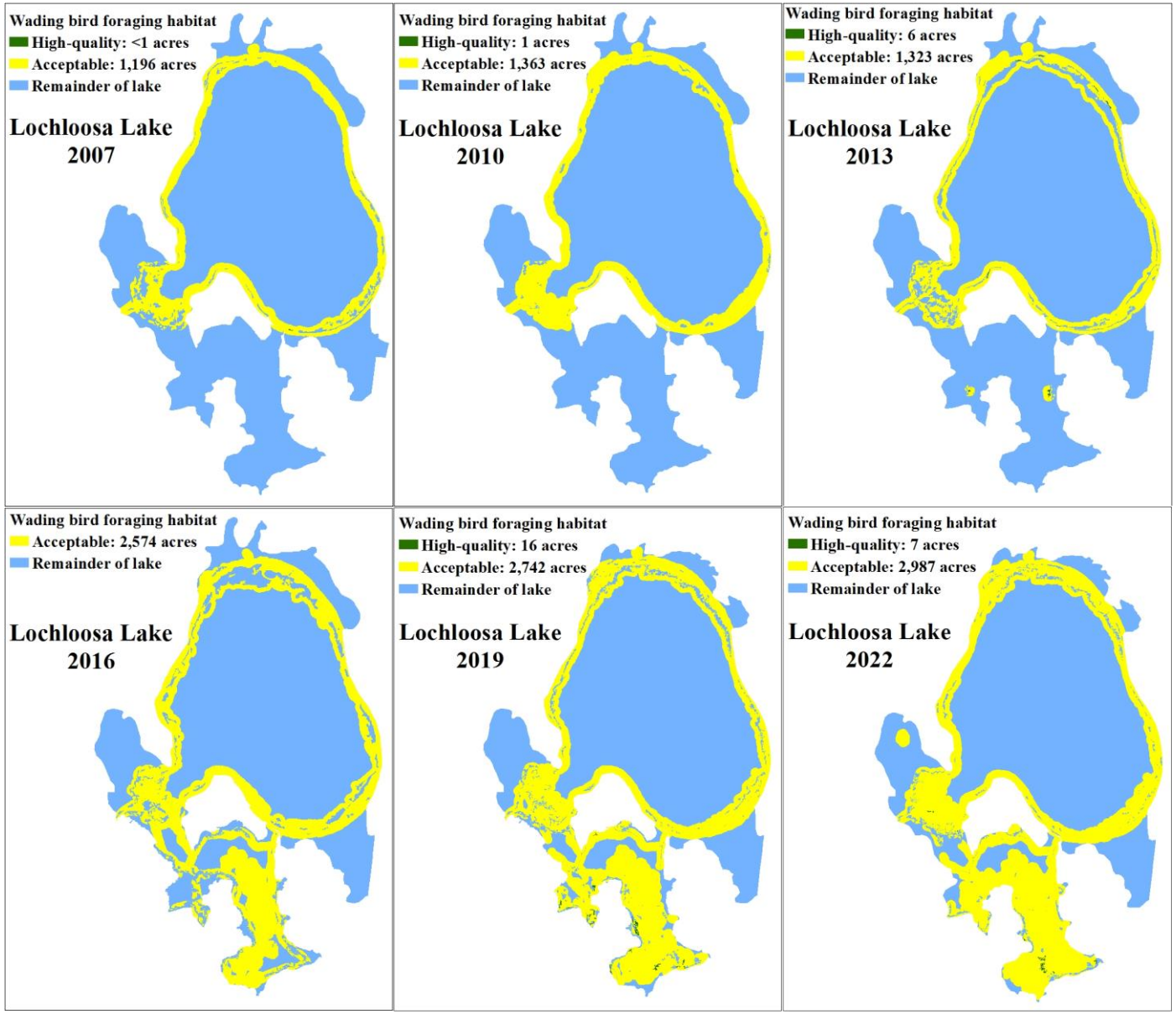

Figure E 6. Location of wading bird foraging habitat identified with GIS analysis of vegetation maps on Lochloosa Lake from 2007 to 2022.

Table E 6. Area (acres) of high-quality and acceptable habitat per habitat type for wading bird roosting in Lochloosa Lake, based on GIS analysis of vegetation maps produced from 2007 to 2022.

Lochloosa Lake	Wading bird roosting					
Habitat type	**2007**	**2010**	**2013**	**2016**	**2019**	**2022**
High-quality habitat						
Open water						
Hardwood swamp						
Tree island	7	15	7	16	12	46
Willow shrub swamp	40	10	8	8	12	10
Complex floating marsh					<1	<1
Tall linear-leaved shallow marsh	2	<1		<1		1
Maidencane shallow marsh						
Mixed shrub swamp	29	19		1	3	2
Flag shallow marsh						
Grass deep marsh						
Low floating marsh						
Mixed shallow marsh						
Floating island						
Floating-leaved deep marsh						
Submersed aquatic vegetation						
Sub-total high-quality habitat	**78**	**44**	**15**	**26**	**28**	**60**
Acceptable habitat						
Open water						
Hardwood swamp	522	419	471	479	539	531
Tree island						
Willow shrub swamp						
Complex floating marsh	82	13	58	33	40	62
Tall linear-leaved shallow marsh	176	211	229	297	249	294
Maidencane shallow marsh						
Mixed shrub swamp	669	257	265	327	522	553
Flag shallow marsh						
Grass deep marsh						
Low floating marsh						
Mixed shallow marsh						
Floating island						
Floating-leaved deep marsh						
Submersed aquatic vegetation						
Sub-total acceptable habitat	**1,449**	**899**	**1,024**	**1,136**	**1,350**	**1,440**
Total habitat	**1,527**	**942**	**1,039**	**1,162**	**1,378**	**1,500**

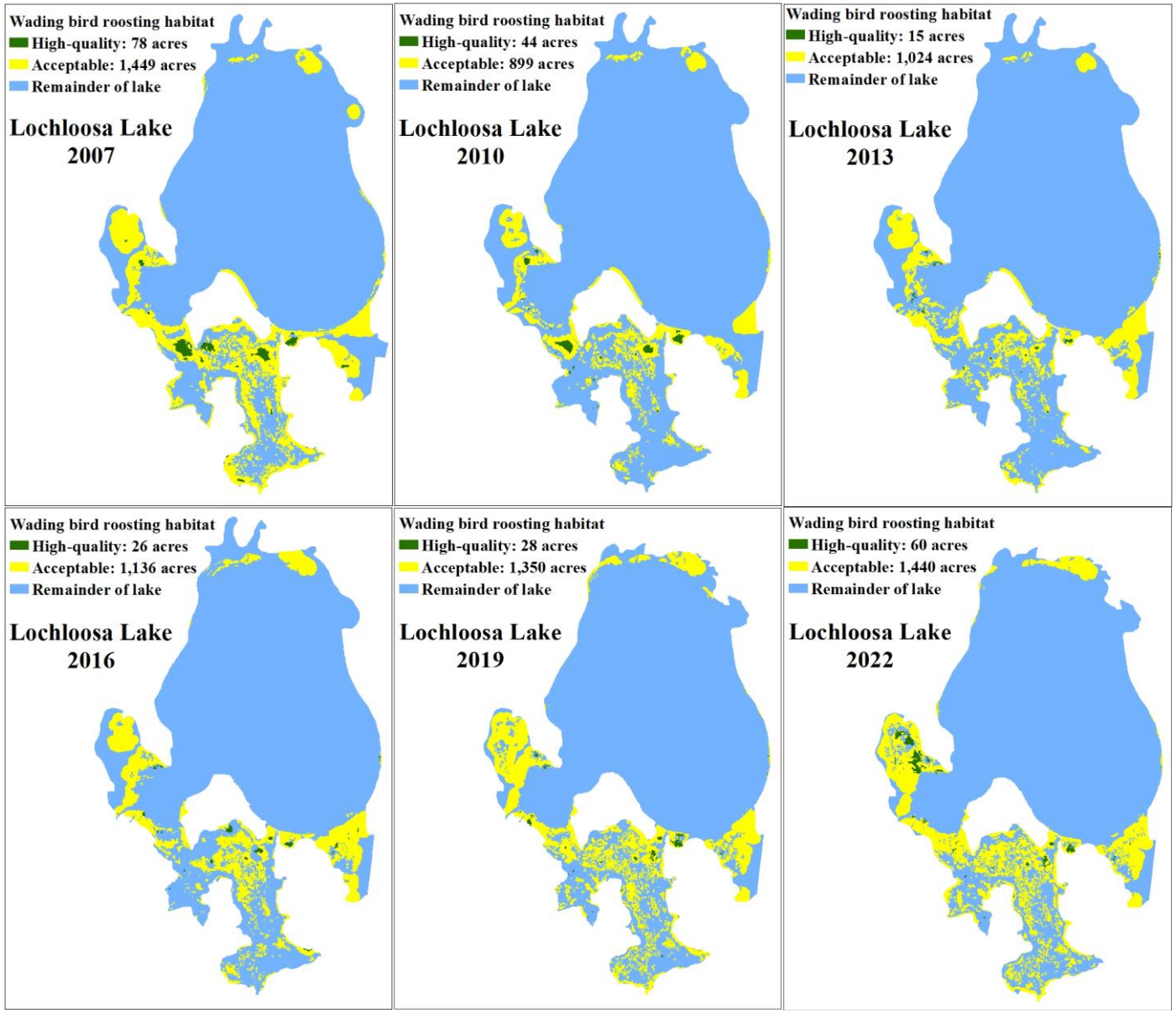

Figure E 7. Location of wading bird roosting habitat identified with GIS analysis of vegetation maps on Lochloosa Lake from 2007 to 2022.

Table E 7. Area (acres) of high-quality and acceptable habitat per habitat type for ring-necked duck in Lochloosa Lake, based on GIS analysis of vegetation maps produced from 2007 to 2022.

Lochloosa Lake	Ring-necked duck					
Habitat type	**2007**	**2010**	**2013**	**2016**	**2019**	**2022**
High-quality habitat						
Open water	415	332	394	540	626	490
Hardwood swamp						
Tree island						
Willow shrub swamp						
Complex floating marsh						
Tall linear-leaved shallow marsh						
Maidencane shallow marsh						
Mixed shrub swamp						
Flag shallow marsh						
Grass deep marsh						
Low floating marsh						
Mixed shallow marsh					<1	1
Floating island						
Floating-leaved deep marsh	131	164	278	493	312	401
Submersed aquatic vegetation	250		2			125
Sub-total high-quality habitat	**796**	**496**	**674**	**1,033**	**939**	**1,018**
Acceptable habitat						
Open water	522	574	472	557	623	538
Hardwood swamp						
Tree island						
Willow shrub swamp						
Complex floating marsh						
Tall linear-leaved shallow marsh	<1					
Maidencane shallow marsh						
Mixed shrub swamp						
Flag shallow marsh		<1	2			
Grass deep marsh	23	28	3	22	26	16
Low floating marsh						
Mixed shallow marsh		8	38	251	291	204
Floating island						
Floating-leaved deep marsh	99	120	215	346	256	440
Submersed aquatic vegetation	44		11	<1	2	38
Sub-total acceptable habitat	**688**	**730**	**740**	**1,176**	**1,198**	**1,236**
Total habitat	**1,484**	**1,226**	**1,414**	**2,209**	**2,137**	**2,254**

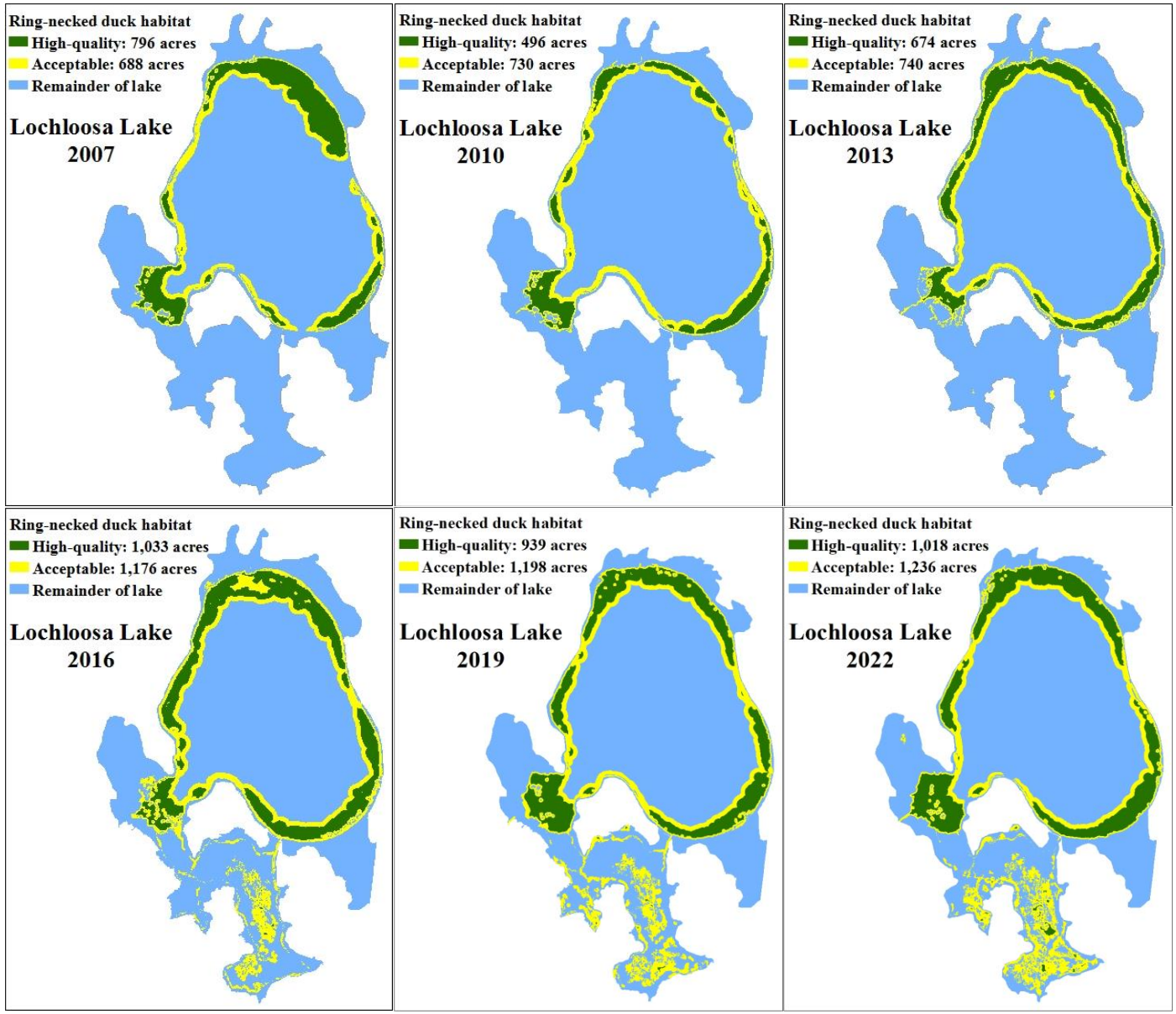

Figure E 8. Location of ring-necked duck habitat identified with GIS analysis of vegetation maps on Lochloosa Lake from 2007 to 2022.

Table E 8. Area (acres) of high-quality and acceptable habitat per habitat type for wood duck in Lochloosa Lake, based on GIS analysis of vegetation maps produced from 2007 to 2022.

Lochloosa Lake	Wood duck					
Habitat type	**2007**	**2010**	**2013**	**2016**	**2019**	**2022**
High-quality habitat						
Open water	204	285	99	255	441	353
Hardwood swamp	87	56	28	38	80	108
Tree island						
Willow shrub swamp	<1		1	1	2	2
Complex floating marsh						
Tall linear-leaved shallow marsh	<1					
Maidencane shallow marsh						
Mixed shrub swamp	10	12	4	22	37	29
Flag shallow marsh		8	25	20	10	30
Grass deep marsh						
Low floating marsh						
Mixed shallow marsh		7	27	105	112	33
Floating island						
Floating-leaved deep marsh	194	204	352	417	370	425
Submersed aquatic vegetation	67		12	<1	2	139
Sub-total high-quality habitat	**562**	**571**	**548**	**858**	**1,054**	**1,119**
Acceptable habitat						
Open water	142	162	126	164	219	161
Hardwood swamp	81	69	55	50	71	88
Tree island						
Willow shrub swamp	1	<1	1	1	2	1
Complex floating marsh	8		1			
Tall linear-leaved shallow marsh						
Maidencane shallow marsh			4	100	18	10
Mixed shrub swamp	9	8	4	27	43	32
Flag shallow marsh		5	12	19	13	23
Grass deep marsh	42	31	17	22	32	30
Low floating marsh						
Mixed shallow marsh	<1	8	17	102	67	27
Floating island		<1			1	1
Floating-leaved deep marsh	30	43	87	143	64	108
Submersed aquatic vegetation	27					20
Sub-total acceptable habitat	**340**	**326**	**324**	**630**	**528**	**500**
Total habitat	**902**	**897**	**872**	**1,488**	**1,582**	**1,620**

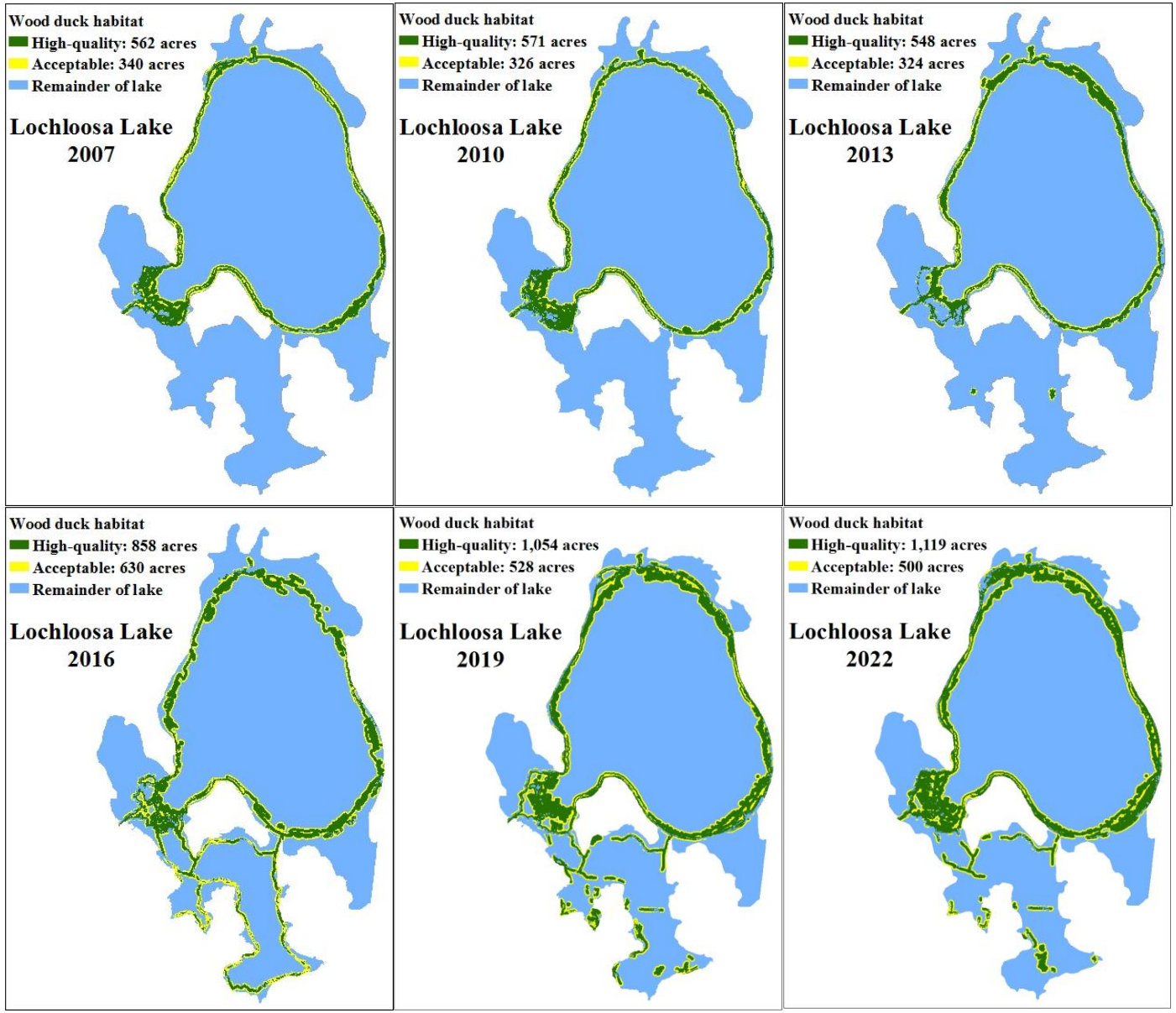

Figure E 9. Location of wood duck habitat identified with GIS analysis of vegetation maps on Lochloosa Lake from 2007 to 2022.

Table E 9. Area (acres) of high-quality and acceptable habitat per habitat type for black crappie in Lochloosa Lake, based on GIS analysis of vegetation maps produced from 2007 to 2022.

Lochloosa Lake	Black crappie					
Habitat type	**2007**	**2010**	**2013**	**2016**	**2019**	**2022**
High-quality habitat						
Open water	5,146	5,367	4,987	4,816	5,253	5040
Hardwood swamp						
Tree island						
Willow shrub swamp						
Complex floating marsh						
Tall linear-leaved shallow marsh						
Maidencane shallow marsh						
Mixed shrub swamp						
Flag shallow marsh						
Grass deep marsh	6	2	1	19	5	2
Low floating marsh						
Mixed shallow marsh						
Floating island						
Floating-leaved deep marsh	38	1	150	174	32	7
Submersed aquatic vegetation						
Sub-total high-quality habitat	**5,189**	**5,370**	**5,138**	**5,010**	**5,291**	**5,049**
Acceptable habitat						
Open water						
Hardwood swamp	108	94	58	61	82	124
Tree island	<1	1	<1	<1	1	3
Willow shrub swamp	<1		2	1	2	3
Complex floating marsh	47	5	41	23	20	25
Tall linear-leaved shallow marsh	<1					
Maidencane shallow marsh	<1	<1	9	102	31	31
Mixed shrub swamp	11	12	5	33	90	154
Flag shallow marsh		21	39	29	20	67
Grass deep marsh	36	29	17	5	27	28
Low floating marsh	21	37	77	50	70	37
Mixed shallow marsh		8	38	251	292	205
Floating island	7	13	7	13	11	11
Floating-leaved deep marsh	192	282	343	664	536	834
Submersed aquatic vegetation	294		12	<1	2	164
Sub-total acceptable habitat	**717**	**502**	**649**	**1,232**	**1,184**	**1,685**
Total habitat	**5,907**	**5,872**	**5,787**	**6,242**	**6,475**	**6,734**

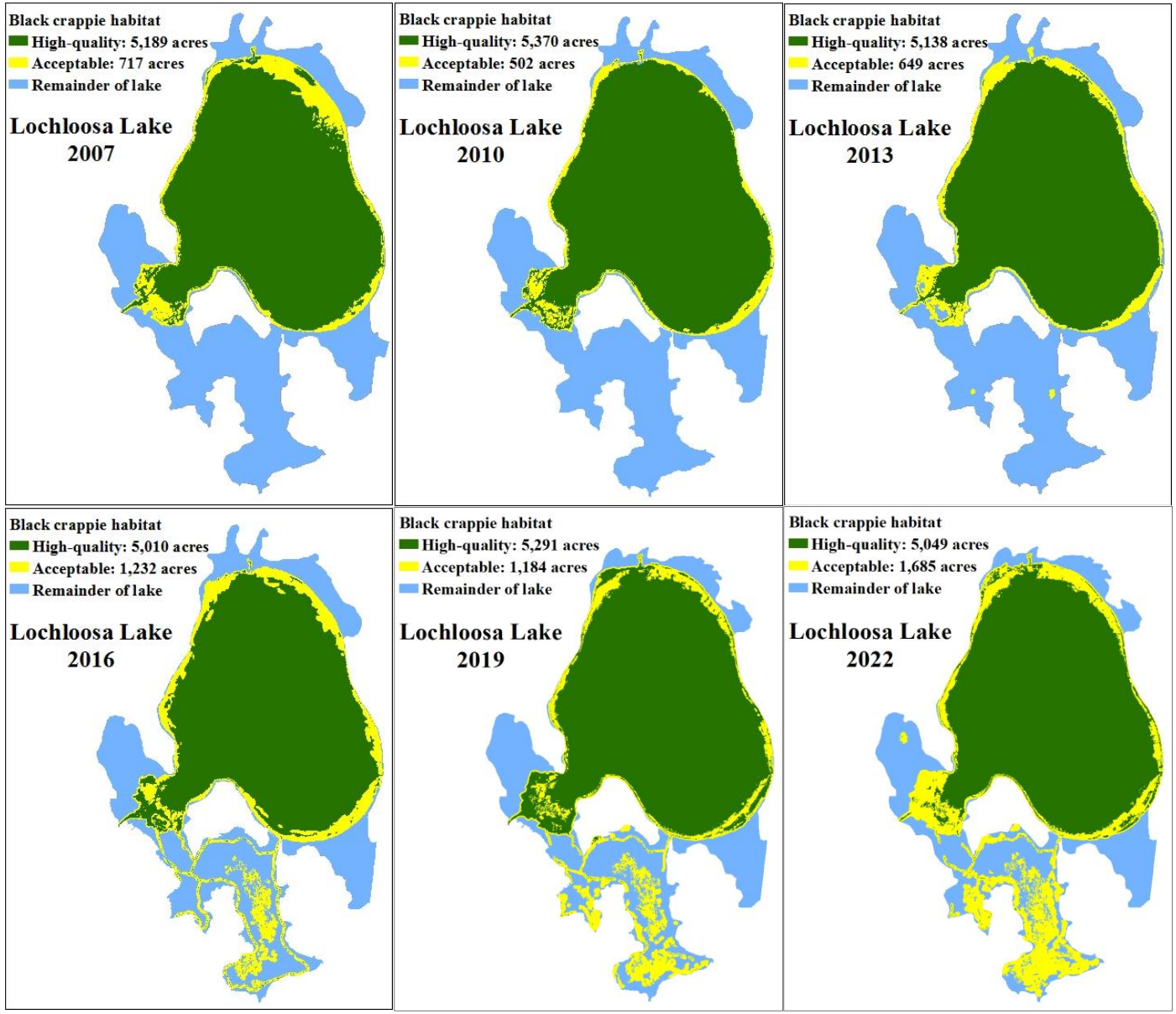

Figure E 10. Location of black crappie habitat identified with GIS analysis of vegetation maps on Lochloosa Lake from 2007 to 2022.

Table E 10. Area (acres) of high-quality and acceptable habitat per habitat type for largemouth bass in Lochloosa Lake, based on GIS analysis of vegetation maps produced from 2007 to 2022.

Lochloosa Lake	Largemouth bass					
Habitat type	**2007**	**2010**	**2013**	**2016**	**2019**	**2022**
High-quality habitat						
Open water	184	124	40	98	248	228
Hardwood swamp						
Tree island						
Willow shrub swamp						
Complex floating marsh						
Tall linear-leaved shallow marsh	<1					
Maidencane shallow marsh						
Mixed shrub swamp						
Flag shallow marsh						
Grass deep marsh	25	29	8	11	28	22
Low floating marsh						
Mixed shallow marsh						
Floating island						
Floating-leaved deep marsh	126	67	208	221	218	281
Submersed aquatic vegetation	121		8	<1	1	147
Sub-total high-quality habitat	**457**	**220**	**263**	**329**	**494**	**678**
Acceptable habitat						
Open water	234	257	169	290	366	238
Hardwood swamp						
Tree island	<1	1	<1	<1	1	3
Willow shrub swamp	<1		2	1	2	3
Complex floating marsh	47	5	40	23	20	25
Tall linear-leaved shallow marsh						
Maidencane shallow marsh						
Mixed shrub swamp	11	12	5	33	85	152
Flag shallow marsh		<1	2			
Grass deep marsh	17	2	10	14	4	7
Low floating marsh	21	37	74	50	70	37
Mixed shallow marsh		<1	2		7	5
Floating island	7	13	8	13	11	11
Floating-leaved deep marsh	103	213	283	618	350	561
Submersed aquatic vegetation	173		4	<1	1	16
Sub-total acceptable habitat	**614**	**540**	**599**	**1,041**	**919**	**1,058**
Total habitat	**1,070**	**760**	**862**	**1,371**	**1,413**	**1,736**

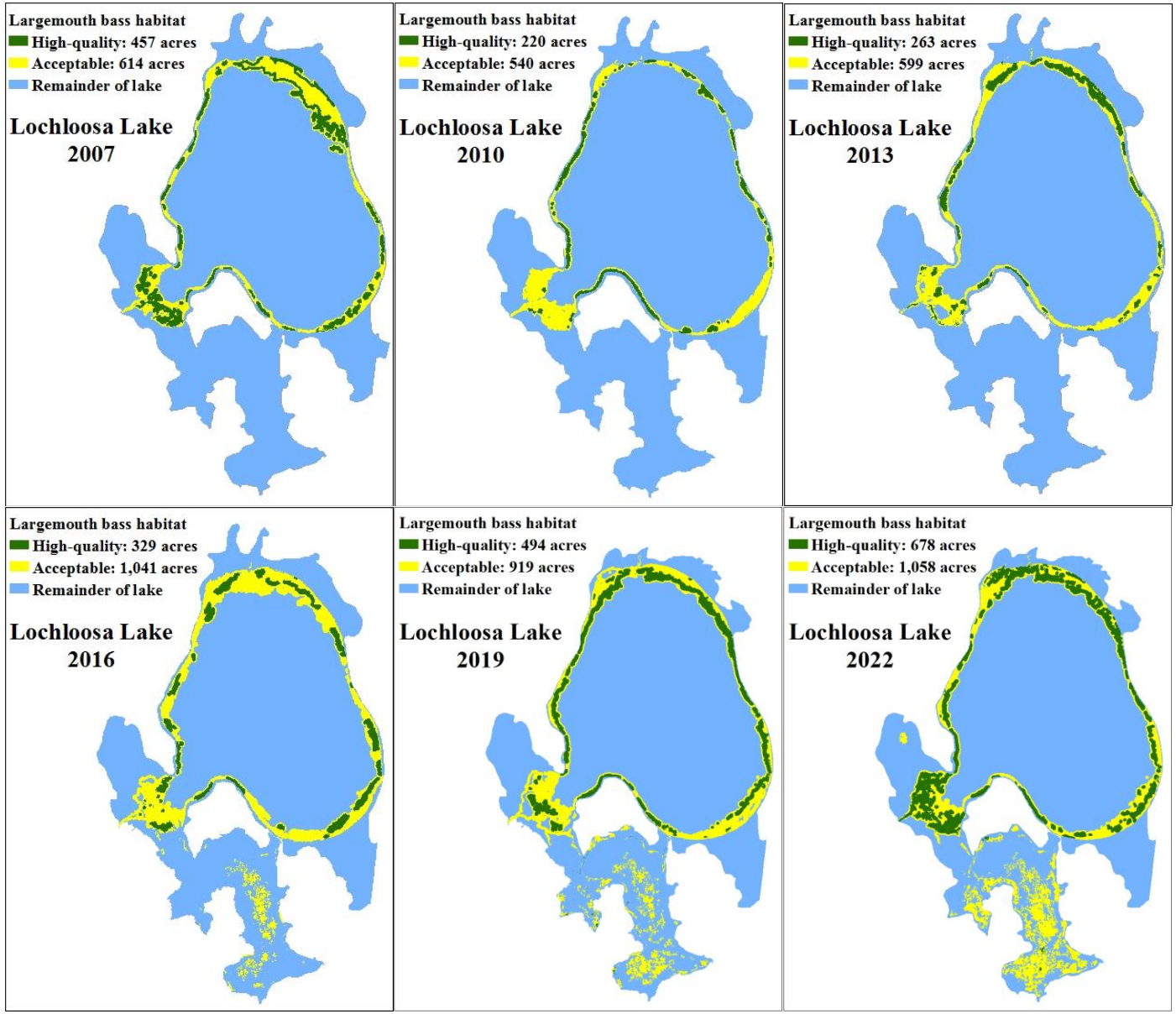

Figure E 11. Location of largemouth bass habitat identified with GIS analysis of vegetation maps on Lochloosa Lake from 2007 to 2022.

APPENDIX F: NEWNANS LAKE HABITAT EVALUATIONS 2007-2022

Craig Mallison, FWRI Freshwater Plants Research

METHODS

Habitat conditions for fish and wildlife on Newnans Lake were evaluated using GIS analysis of vegetation maps created in 2007, 2010, 2013, 2016, 2019, and 2022 (Figure F 1). Methods were the same as those for Orange Lake (Appendix D).

RESULTS

Results for individual focal taxa analyses on Newnans Lake (2007, 2010, 2013, 2016, 2019, and 2022) are presented in Tables F 1-10 and Figures F 2-11. Results for combined analysis are presented in Figure 13 (not duplicated in Appendix F).

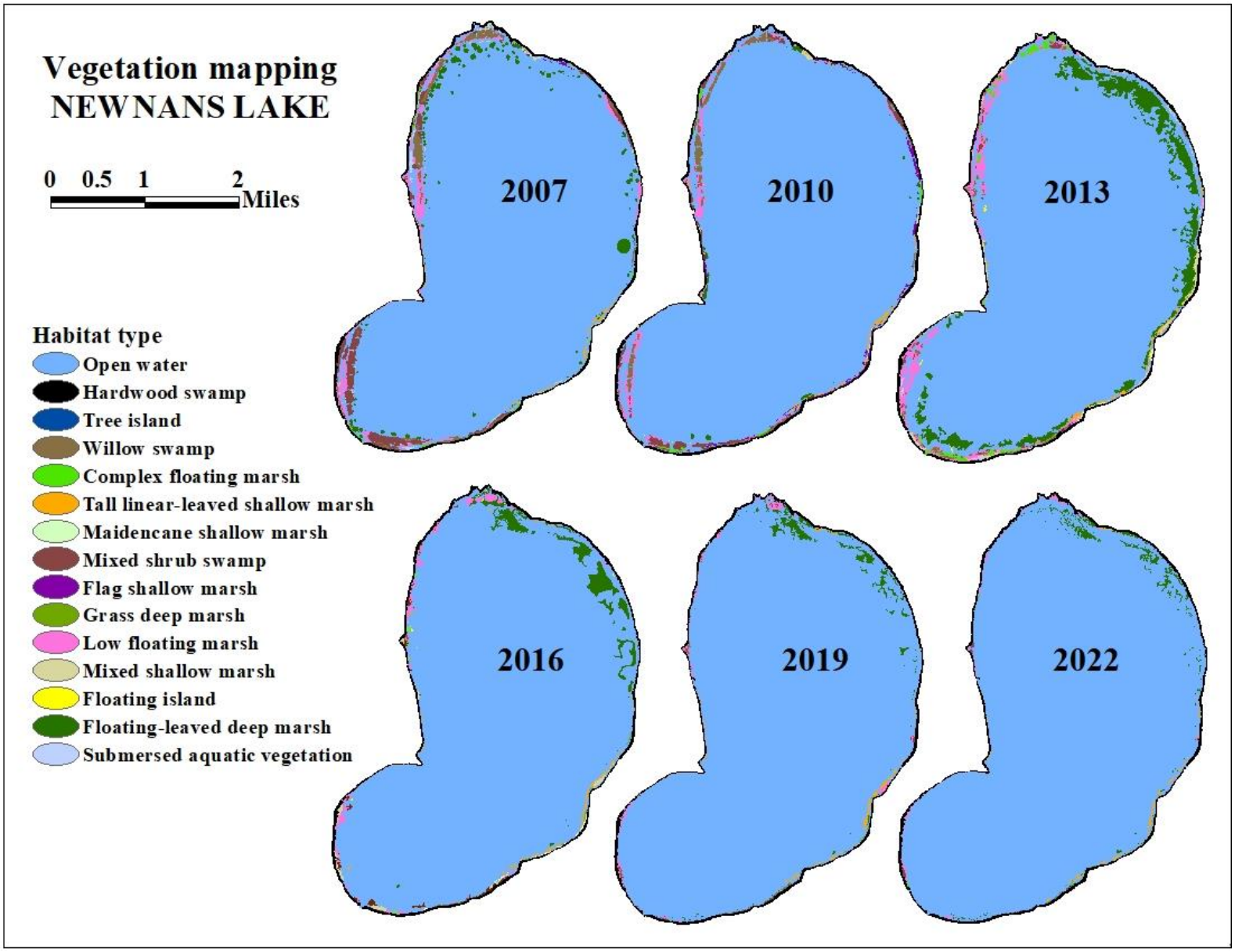

Figure F 1. Newnans Lake littoral vegetation maps from 2007 to 2022.

Table F 1. Area (acres) of high-quality and acceptable habitat per habitat type for alligator foraging in Newnans Lake, based on GIS analysis of vegetation maps produced from 2007 to 2022.

Newnans Lake	Alligator foraging					
Habitat type	**2007**	**2010**	**2013**	**2016**	**2019**	**2022**
High-quality habitat						
Open water	915	774	1,001	890	847	849
Hardwood swamp						
Tree island						
Willow shrub swamp						
Complex floating marsh			11			
Tall linear-leaved shallow marsh	8	4	11	3	13	9
Maidencane shallow marsh						
Mixed shrub swamp						
Flag shallow marsh	3	33				
Grass deep marsh			2	3	4	3
Low floating marsh						
Mixed shallow marsh	12	6	22	<1	<1	
Floating island		<1	1	1	<1	
Floating-leaved deep marsh	76	19	308	112	52	45
Submersed aquatic vegetation	14	<1	8			
Sub-total high-quality habitat	**1,029**	**836**	**1,364**	**1,010**	**915**	**905**
Acceptable habitat						
Open water	4,612	4,879	4,314	4,799	4,964	4,986
Hardwood swamp	14	18	17	22	25	26
Tree island		<1			<1	<1
Willow shrub swamp	9	52	5	2	2	1
Complex floating marsh	3	2	5	2	<1	<1
Tall linear-leaved shallow marsh	3	9	4	9	4	5
Maidencane shallow marsh	<1	1	4	4		
Mixed shrub swamp	15	7	4	6	3	2
Flag shallow marsh	<1	2	<1			
Grass deep marsh				<1	<1	<1
Low floating marsh	24	27	40	12	7	5
Mixed shallow marsh	<1	<1	4	3	<1	
Floating island						
Floating-leaved deep marsh	16	1	34	25	22	18
Submersed aquatic vegetation						
Sub-total acceptable habitat	**4,698**	**4,999**	**4,431**	**4,883**	**5,028**	**5,044**
Total habitat	**5,726**	**5,835**	**5,796**	**5,893**	**5,943**	**5,949**

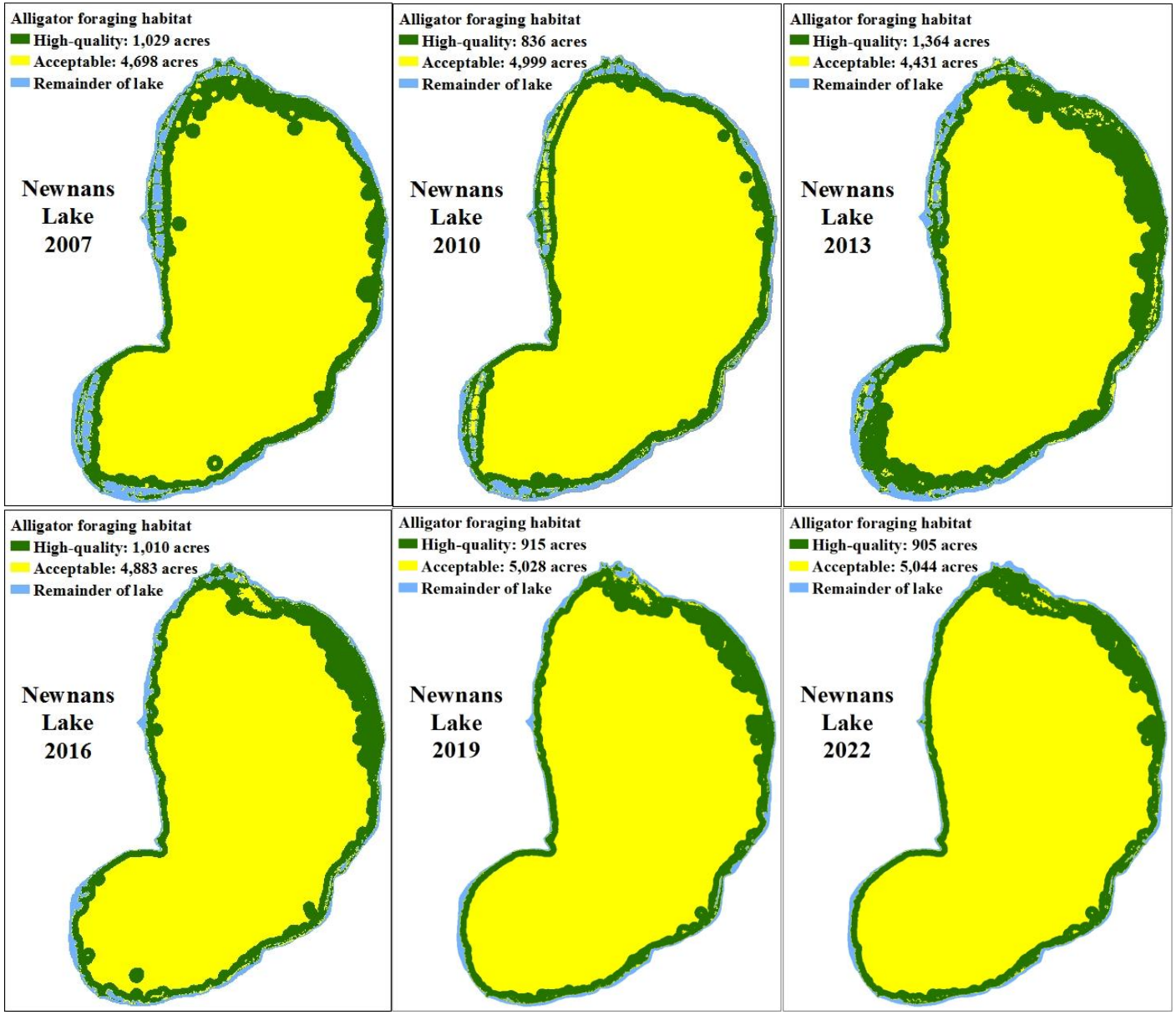

Figure F 2. Location of alligator foraging habitat identified with GIS analysis of vegetation maps on Newnans Lake from 2007 to 2022.

Table F 2. Area (acres) of high-quality and acceptable habitat per habitat type for alligator nesting in Newnans Lake, based on GIS analysis of vegetation maps produced from 2007 to 2022.

Newnans Lake	Alligator nesting					
Habitat type	**2007**	**2010**	**2013**	**2016**	**2019**	**2022**
High-quality habitat						
Open water						
Hardwood swamp						
Tree island		<1			<1	<1
Willow shrub swamp						
Complex floating marsh	10	11	29	5	<1	1
Tall linear-leaved shallow marsh	12	19	13	18	17	16
Maidencane shallow marsh	<1	<1	1	2		
Mixed shrub swamp						
Flag shallow marsh	<1	4	2		<1	
Grass deep marsh						
Low floating marsh	91	76	138	49	30	17
Mixed shallow marsh	1	2	18	18	<1	
Floating island		<1	3	2	<1	
Floating-leaved deep marsh						
Submersed aquatic vegetation						
Sub-total high-quality habitat	**115**	**113**	**204**	**93**	**48**	**34**
Acceptable habitat						
Open water						
Hardwood swamp						
Tree island						
Willow shrub swamp	76	77	35	5	6	1
Complex floating marsh			4			
Tall linear-leaved shallow marsh	1	<1	5	<1	4	1
Maidencane shallow marsh	<1	1	1	3		
Mixed shrub swamp	121	55	17	21	10	5
Flag shallow marsh	3	33				
Grass deep marsh						
Low floating marsh						
Mixed shallow marsh	8	6	4	<1	<1	
Floating island		<1		<1	<1	
Floating-leaved deep marsh						
Submersed aquatic vegetation						
Sub-total acceptable habitat	**209**	**172**	**65**	**29**	**21**	**8**
Total habitat	**324**	**285**	**269**	**122**	**68**	**42**

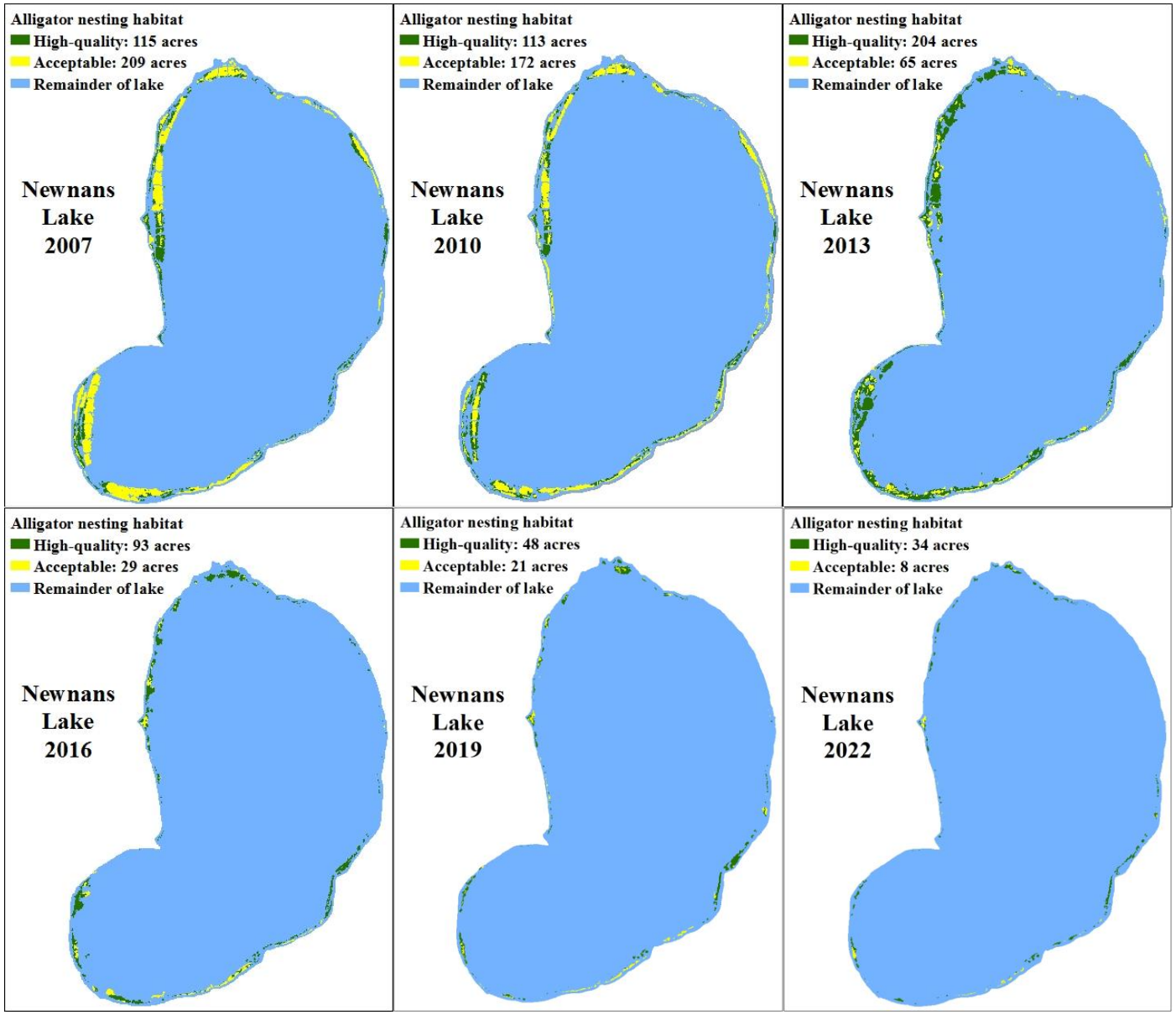

Figure F 3. Location of alligator nesting habitat identified with GIS analysis of vegetation maps on Newnans Lake from 2007 to 2022.

Table F 3. Area (acres) of high-quality and acceptable habitat per habitat type for herpetofauna in Newnans Lake, based on GIS analysis of vegetation maps produced from 2007 to 2022.

Newnans Lake	Herpetofauna					
Habitat type	**2007**	**2010**	**2013**	**2016**	**2019**	**2022**
High-quality habitat						
Open water	153	153	182	94	49	37
Hardwood swamp	79	53	99	63	40	36
Tree island					<1	
Willow shrub swamp	37	44	32	4	2	<1
Complex floating marsh	10	11	39	5	<1	1
Tall linear-leaved shallow marsh	4	3	8	4	2	1
Maidencane shallow marsh	<1	<1	1	1		
Mixed shrub swamp	31	29	16	14	7	3
Flag shallow marsh	1	4	2		<1	
Grass deep marsh			2	<1	<1	
Low floating marsh	91	76	138	49	30	17
Mixed shallow marsh	14	8	40	18	<1	
Floating island		<1	3	2	<1	
Floating-leaved deep marsh	9	3	17	11	2	2
Submersed aquatic vegetation	9		7			
Sub-total high-quality habitat	**438**	**385**	**584**	**265**	**134**	**96**
Acceptable habitat						
Open water	136	170	61	151	184	203
Hardwood swamp	21	26	9	24	30	38
Tree island					<1	<1
Willow shrub swamp	39	32	3	1	4	1
Complex floating marsh			<1			
Tall linear-leaved shallow marsh	8	17	9	14	17	16
Maidencane shallow marsh	<1	1	4	4		
Mixed shrub swamp	90	26	1	6	3	2
Flag shallow marsh	2	30	<1			
Grass deep marsh			<1	3	4	3
Low floating marsh						
Mixed shallow marsh						
Floating island						
Floating-leaved deep marsh	25	9	104	30	27	26
Submersed aquatic vegetation	5	<1	1			
Sub-total acceptable habitat	**327**	**311**	**191**	**232**	**269**	**290**
Total habitat	**765**	**696**	**775**	**497**	**403**	**386**

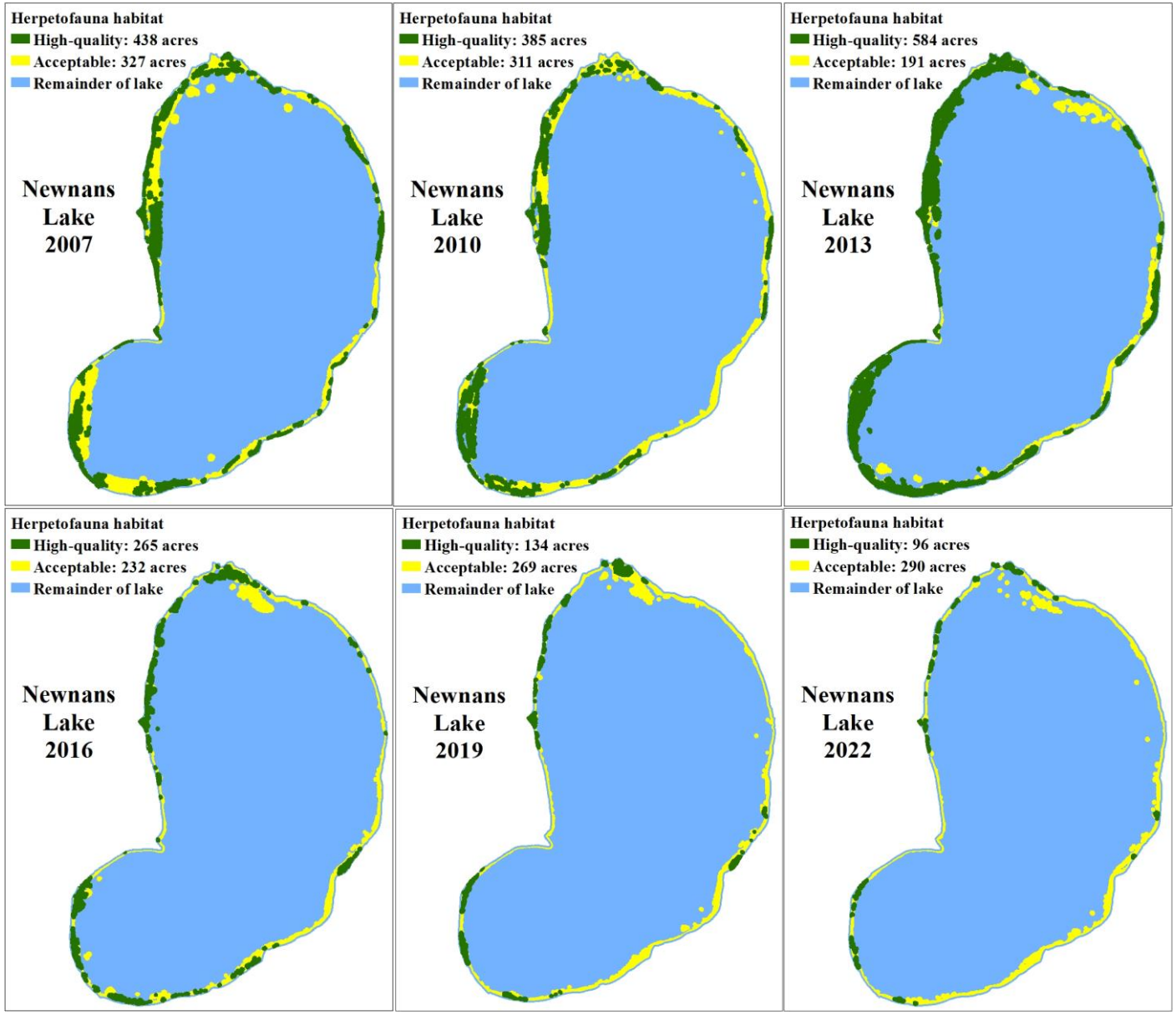

Figure F 4. Location of herpetofauna habitat identified with GIS analysis of vegetation maps on Newnans Lake from 2007 to 2022.

Table F 4. Area (acres) of high-quality and acceptable habitat per habitat type for round-tailed muskrat in Newnans Lake, based on GIS analysis of vegetation maps produced from 2007 to 2022.

Newnans Lake	Round-tailed muskrat					
Habitat type	**2007**	**2010**	**2013**	**2016**	**2019**	**2022**
High-quality habitat						
Open water						
Hardwood swamp						
Tree island						
Willow shrub swamp						
Complex floating marsh						
Tall linear-leaved shallow marsh		2	2	5		
Maidencane shallow marsh		1	5	6		
Mixed shrub swamp						
Flag shallow marsh		<1	<1			
Grass deep marsh				<1		
Low floating marsh			3	1		
Mixed shallow marsh				1		
Floating island						
Floating-leaved deep marsh						
Submersed aquatic vegetation						
Sub-total high-quality habitat	**0**	**2**	**10**	**13**	**0**	**0**
Acceptable habitat						
Open water						
Hardwood swamp						
Tree island						
Willow shrub swamp						
Complex floating marsh	8	8	29	4	<1	1
Tall linear-leaved shallow marsh	10	17	9	13	16	15
Maidencane shallow marsh	<1	<1		<1		
Mixed shrub swamp						
Flag shallow marsh	1	27	2		<1	
Grass deep marsh			2	1	2	1
Low floating marsh	91	76	135	48	30	17
Mixed shallow marsh	6	6	21	17	<1	
Floating island		<1	1	1	<1	
Floating-leaved deep marsh	33	9	36	13	15	17
Submersed aquatic vegetation						
Sub-total acceptable habitat	**150**	**144**	**234**	**98**	**64**	**51**
Total habitat	**150**	**147**	**244**	**110**	**64**	**51**

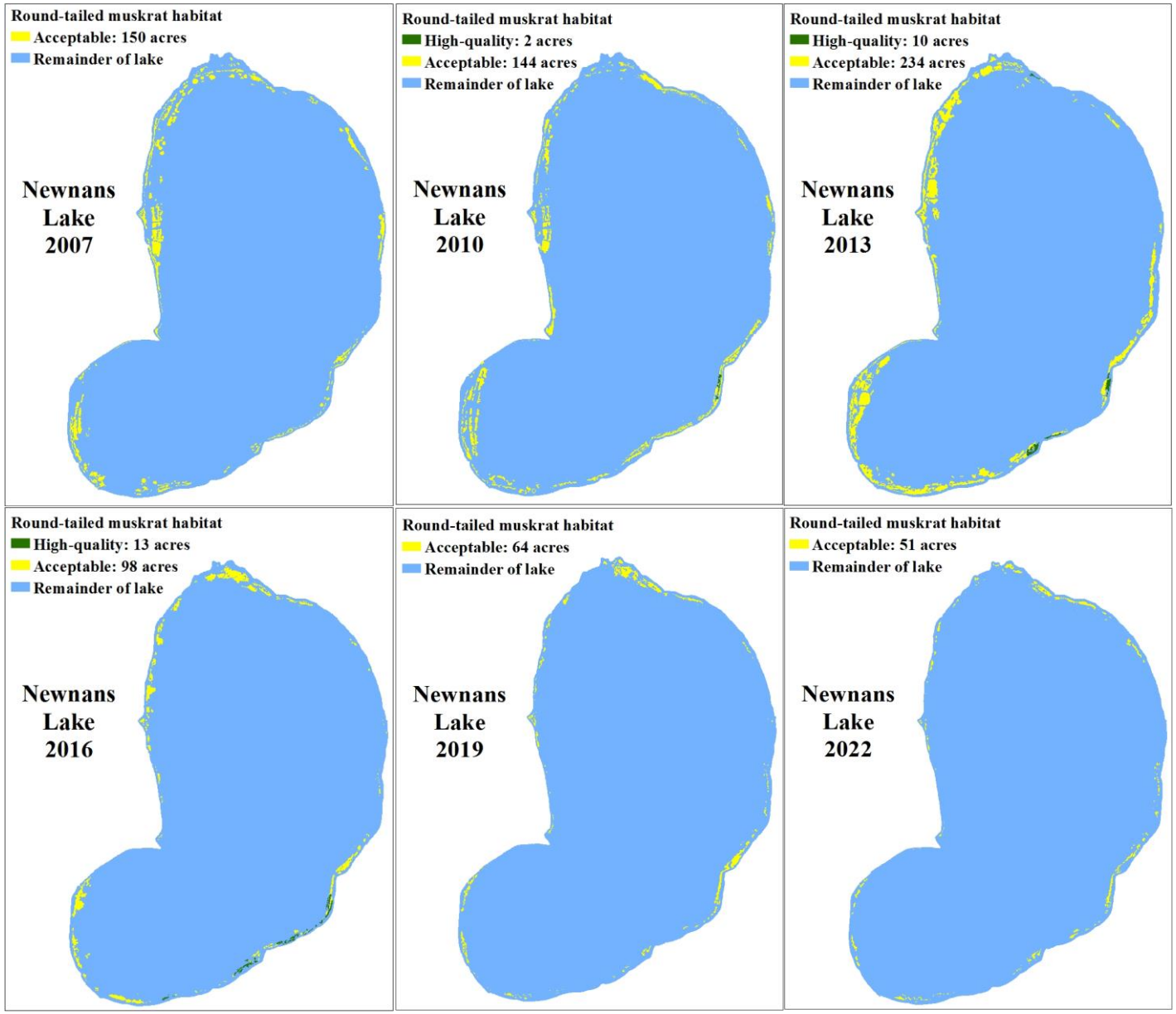

Figure F 5. Location of round-tailed muskrat habitat identified with GIS analysis of vegetation maps on Newnans Lake from 2007 to 2022.

Table F 5. Area (acres) of high-quality and acceptable habitat per habitat type for wading bird foraging in Newnans Lake, based on GIS analysis of vegetation maps produced from 2007 to 2022.

Newnans Lake	Wading bird foraging					
Habitat type	**2007**	**2010**	**2013**	**2016**	**2019**	**2022**
High-quality habitat						
Open water						
Hardwood swamp						
Tree island						
Willow shrub swamp						
Complex floating marsh						
Tall linear-leaved shallow marsh	8	4	6	3	9	7
Maidencane shallow marsh			3	1		
Mixed shrub swamp						
Flag shallow marsh	3	33				
Grass deep marsh						
Low floating marsh						
Mixed shallow marsh	12	6	22	<1	<1	
Floating island		<1		<1	<1	
Floating-leaved deep marsh						
Submersed aquatic vegetation						
Sub-total high-quality habitat	**23**	**43**	**31**	**4**	**9**	**7**
Acceptable habitat						
Open water	915	774	1,001	890	847	849
Hardwood swamp	182	192	177	197	190	204
Tree island		<1			<1	<1
Willow shrub swamp	76	77	34	5	6	1
Complex floating marsh			4			
Tall linear-leaved shallow marsh	5	16	13	15	12	10
Maidencane shallow marsh	<1	1	1	3		
Mixed shrub swamp	121	55	17	21	10	5
Flag shallow marsh	<1	4	2		<1	
Grass deep marsh			2	3	4	3
Low floating marsh	91	76	138	49	30	17
Mixed shallow marsh	1	2	18	17	<1	
Floating island		<1	3	2	<1	
Floating-leaved deep marsh	16	1	34	25	22	18
Submersed aquatic vegetation	14	<1	8			
Sub-total acceptable habitat	**1,422**	**1,198**	**1,451**	**1,226**	**1,122**	**1,108**
Total habitat	**1,445**	**1,241**	**1,482**	**1,231**	**1,132**	**1,115**

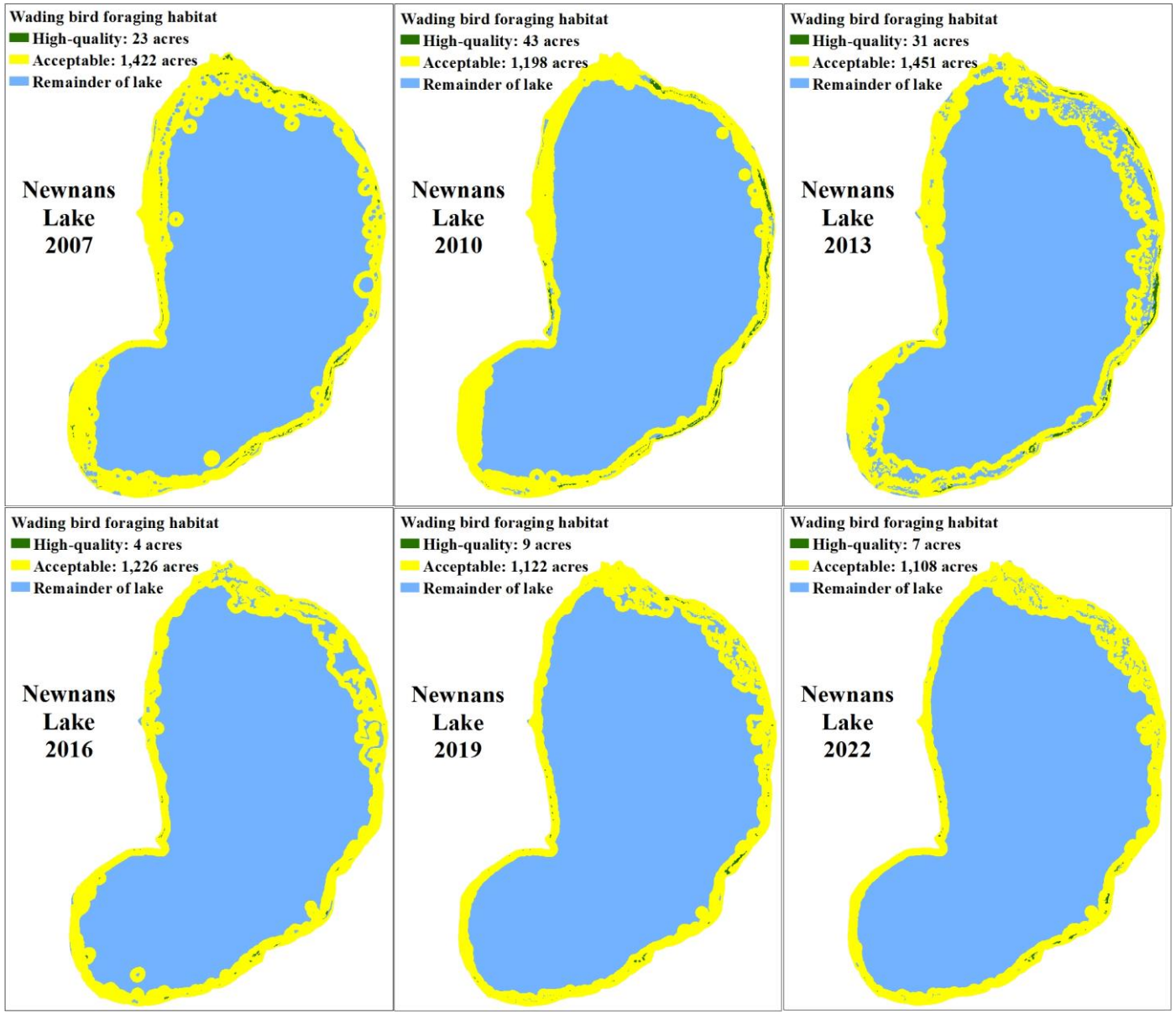

Figure F 6. Location of wading bird foraging habitat identified with GIS analysis of vegetation maps on Newnans Lake from 2007 to 2022.

Table F 6. Area (acres) of high-quality and acceptable habitat per habitat type for wading bird roosting in Newnans Lake, based on GIS analysis of vegetation maps produced from 2007 to 2022.

Newnans Lake	Wading bird roosting					
Habitat type	**2007**	**2010**	**2013**	**2016**	**2019**	**2022**
High-quality habitat						
Open water						
Hardwood swamp						
Tree island		<1			<1	<1
Willow shrub swamp	76	77	35	5	6	1
Complex floating marsh						
Tall linear-leaved shallow marsh						
Maidencane shallow marsh						
Mixed shrub swamp						
Flag shallow marsh						
Grass deep marsh						
Low floating marsh						
Mixed shallow marsh						
Floating island						
Floating-leaved deep marsh						
Submersed aquatic vegetation						
Sub-total high-quality habitat	**76**	**77**	**35**	**5**	**7**	**1**
Acceptable habitat						
Open water						
Hardwood swamp	158	166	104	126	113	82
Tree island						
Willow shrub swamp						
Complex floating marsh	10	11	29	5	<1	1
Tall linear-leaved shallow marsh	4	16	8	15	8	9
Maidencane shallow marsh						
Mixed shrub swamp	121	55	17	21	10	5
Flag shallow marsh						
Grass deep marsh						
Low floating marsh						
Mixed shallow marsh						
Floating island						
Floating-leaved deep marsh						
Submersed aquatic vegetation						
Sub-total acceptable habitat	**293**	**248**	**158**	**165**	**131**	**98**
Total habitat	**369**	**325**	**192**	**171**	**137**	**99**

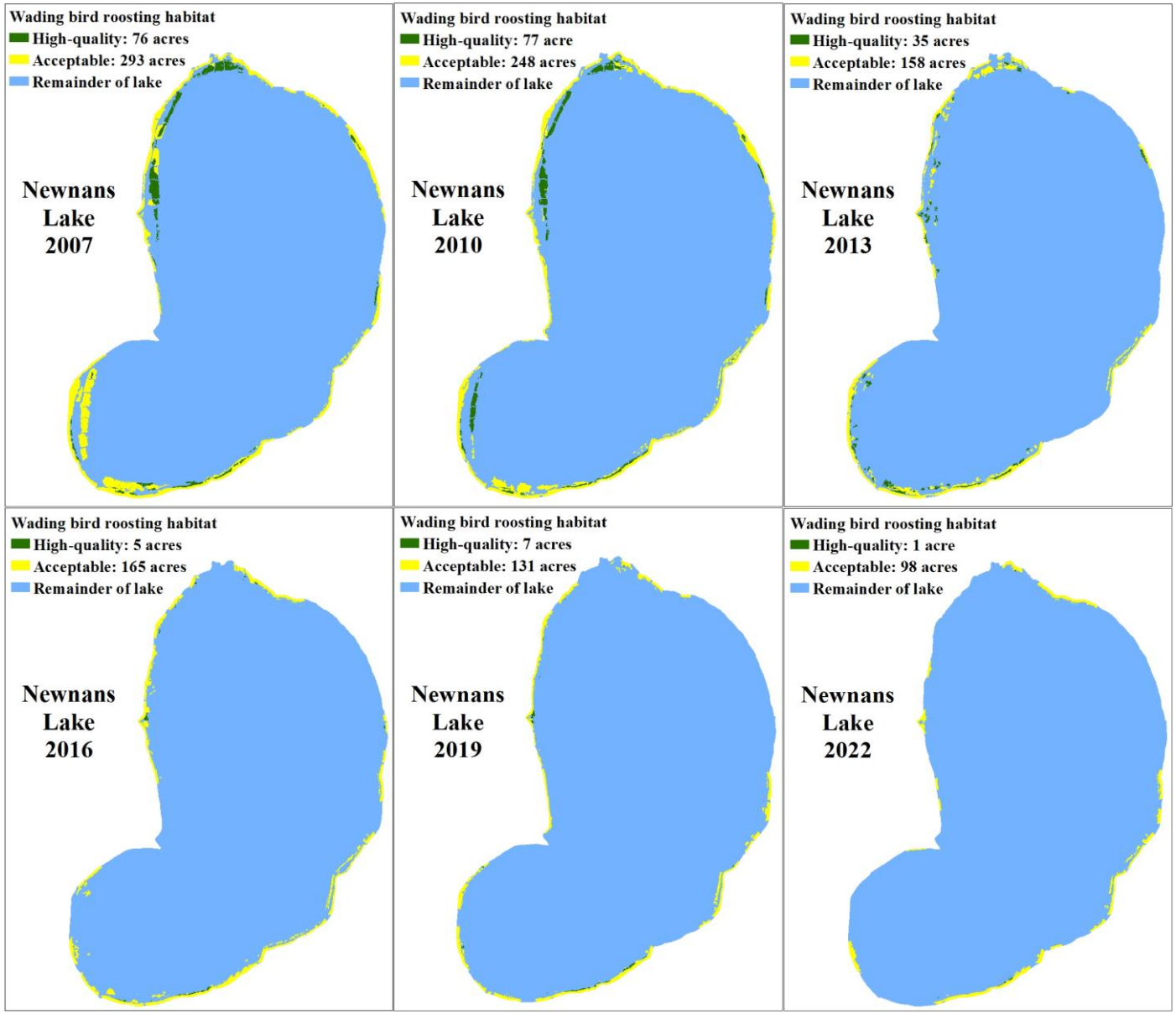

Figure F 7. Location of wading bird roosting habitat identified with GIS analysis of vegetation maps on Newnans Lake from 2007 to 2022.

Table F 7. Area (acres) of high-quality and acceptable habitat per habitat type for ring-necked duck in Newnans Lake, based on GIS analysis of vegetation maps produced from 2007 to 2022.

Newnans Lake	Ring-necked duck					
Habitat type	**2007**	**2010**	**2013**	**2016**	**2019**	**2022**
High-quality habitat						
Open water	564	185	640	416	469	476
Hardwood swamp						
Tree island						
Willow shrub swamp						
Complex floating marsh						
Tall linear-leaved shallow marsh	4	<1	3	1	4	3
Maidencane shallow marsh						
Mixed shrub swamp						
Flag shallow marsh	<1	<1				
Grass deep marsh						
Low floating marsh						
Mixed shallow marsh	2	1	3			
Floating island						
Floating-leaved deep marsh	75	9	303	92	63	52
Submersed aquatic vegetation	1		1			
Sub-total high-quality habitat	**646**	**195**	**949**	**509**	**536**	**531**
Acceptable habitat						
Open water	703	566	532	526	517	521
Hardwood swamp						
Tree island						
Willow shrub swamp						
Complex floating marsh						
Tall linear-leaved shallow marsh	4	4	8	2	9	6
Maidencane shallow marsh	<1	1	3	4		
Mixed shrub swamp						
Flag shallow marsh	3	31				
Grass deep marsh			2	3	4	3
Low floating marsh						
Mixed shallow marsh	11	7	32	12	<1	
Floating island						
Floating-leaved deep marsh	18	11	39	45	11	11
Submersed aquatic vegetation	13	<1	8			
Sub-total acceptable habitat	**751**	**620**	**623**	**592**	**541**	**541**
Total habitat	**1,398**	**814**	**1,572**	**1,102**	**1,077**	**1,072**

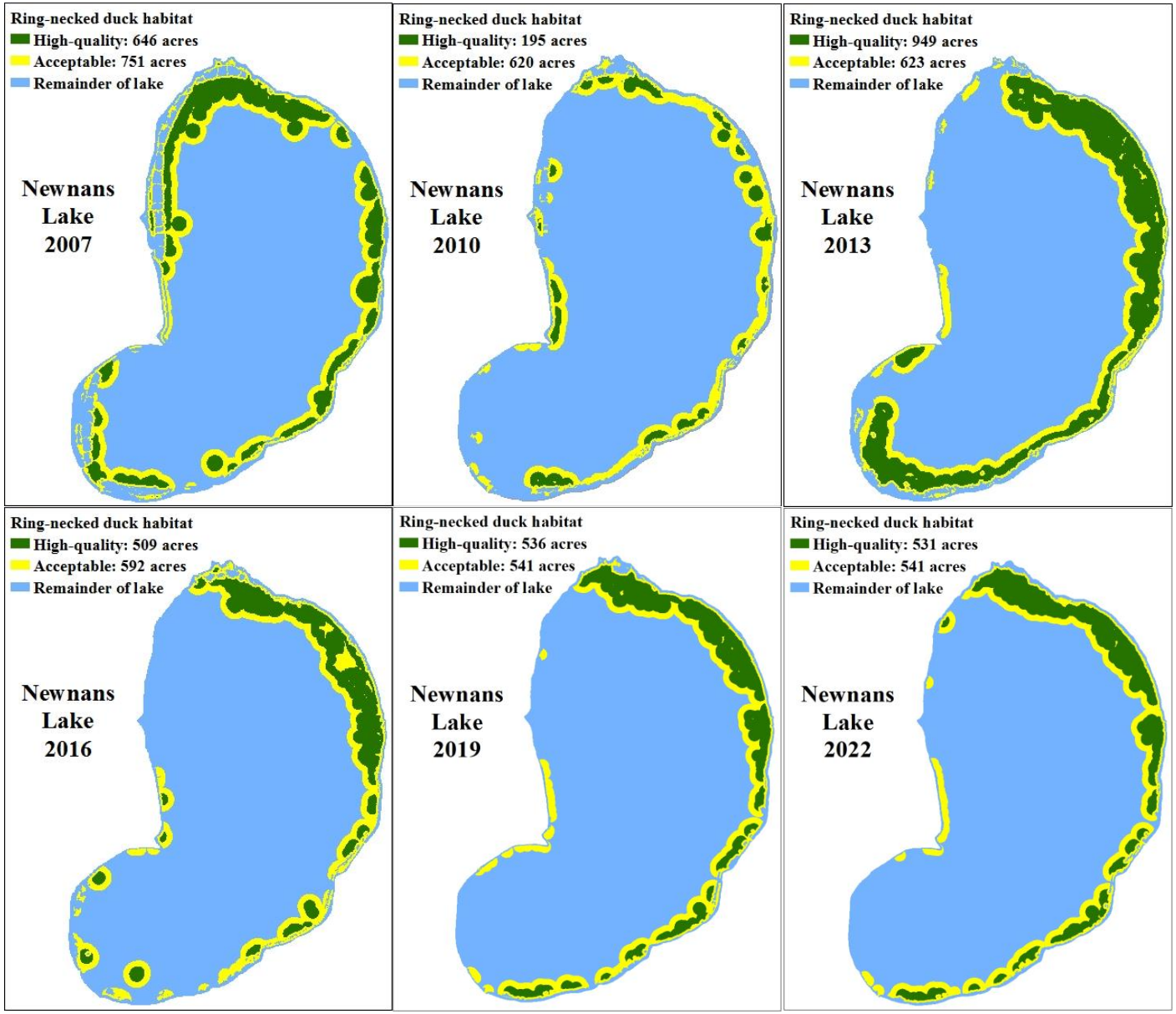

Figure F 8. Location of ring-necked duck habitat identified with GIS analysis of vegetation maps on Newnans Lake from 2007 to 2022.

Table F 8. Area (acres) of high-quality and acceptable habitat per habitat type for wood duck in Newnans Lake, based on GIS analysis of vegetation maps produced from 2007 to 2022.

Newnans Lake	Wood duck					
Habitat type	**2007**	**2010**	**2013**	**2016**	**2019**	**2022**
High-quality habitat						
Open water	387	333	288	254	295	327
Hardwood swamp	97	116	103	127	135	143
Tree island						
Willow shrub swamp	46	69	23	5	6	1
Complex floating marsh						
Tall linear-leaved shallow marsh	8	4	6	3	9	7
Maidencane shallow marsh	<1	1	4	4		
Mixed shrub swamp	79	40	13	17	8	4
Flag shallow marsh	3	37	1		<1	
Grass deep marsh						
Low floating marsh						
Mixed shallow marsh	12	8	33	12	<1	
Floating island						
Floating-leaved deep marsh	86	14	226	37	50	51
Submersed aquatic vegetation	13	<1	8			
Sub-total high-quality habitat	**732**	**622**	**704**	**459**	**504**	**533**
Acceptable habitat						
Open water	230	185	210	189	201	222
Hardwood swamp	60	59	48	52	46	53
Tree island						
Willow shrub swamp	24	7	8	<1	<1	<1
Complex floating marsh			11			
Tall linear-leaved shallow marsh	1	<1	5	<1	4	1
Maidencane shallow marsh	<1	<1	1	2		
Mixed shrub swamp	34	13	4	3	2	1
Flag shallow marsh	<1	<1	1		<1	
Grass deep marsh			2	3	4	3
Low floating marsh						
Mixed shallow marsh	1	<1	4	4		
Floating island		<1		<1	<1	
Floating-leaved deep marsh	5	1	38	14	4	3
Submersed aquatic vegetation	1		1			
Sub-total acceptable habitat	**356**	**266**	**331**	**268**	**262**	**285**
Total habitat	**1,089**	**888**	**1,035**	**727**	**765**	**817**

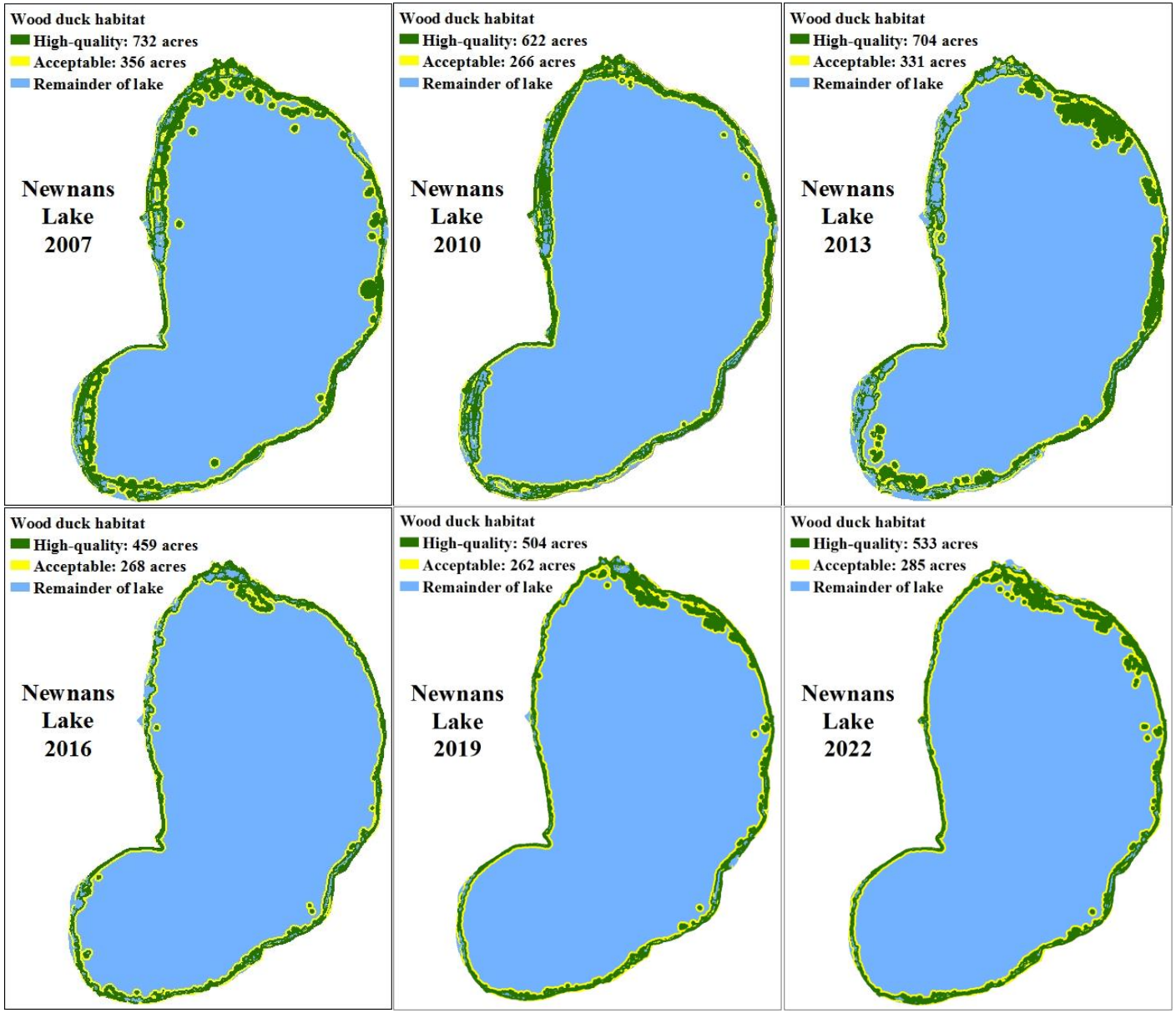

Figure F 9. Location of wood duck habitat identified with GIS analysis of vegetation maps on Newnans Lake from 2007 to 2022.

Table F 9. Area (acres) of high-quality and acceptable habitat per habitat type for black crappie in Newnans Lake, based on GIS analysis of vegetation maps produced from 2007 to 2022.

Newnans Lake	Black crappie					
Habitat type	**2007**	**2010**	**2013**	**2016**	**2019**	**2022**
High-quality habitat						
Open water	5,527	5,654	5,316	5,689	5,811	5,835
Hardwood swamp						
Tree island						
Willow shrub swamp						
Complex floating marsh						
Tall linear-leaved shallow marsh	1	<1	5	<1	4	1
Maidencane shallow marsh						
Mixed shrub swamp						
Flag shallow marsh						
Grass deep marsh				1	<1	<1
Low floating marsh						
Mixed shallow marsh						
Floating island						
Floating-leaved deep marsh	6	10	221	104	23	14
Submersed aquatic vegetation						
Sub-total high-quality habitat	**5,534**	**5,664**	**5,542**	**5,794**	**5,838**	**5,851**
Acceptable habitat						
Open water						
Hardwood swamp	97	116	103	127	137	146
Tree island		<1			<1	<1
Willow shrub swamp	46	69	23	5	6	1
Complex floating marsh	10	10	32	4	<1	1
Tall linear-leaved shallow marsh	8	4	6	3	9	7
Maidencane shallow marsh	<1	1	4	6		
Mixed shrub swamp	79	40	13	17	8	4
Flag shallow marsh	3	37	1		<1	
Grass deep marsh			2	1	4	3
Low floating marsh	79	72	112	41	25	16
Mixed shallow marsh	13	8	35	12	<1	
Floating island		<1	3	2	<1	
Floating-leaved deep marsh	86	9	121	33	51	49
Submersed aquatic vegetation	14	<1	8			
Sub-total acceptable habitat	**436**	**366**	**461**	**252**	**240**	**227**
Total habitat	**5,970**	**6,030**	**6,003**	**6,046**	**6,078**	**6,078**

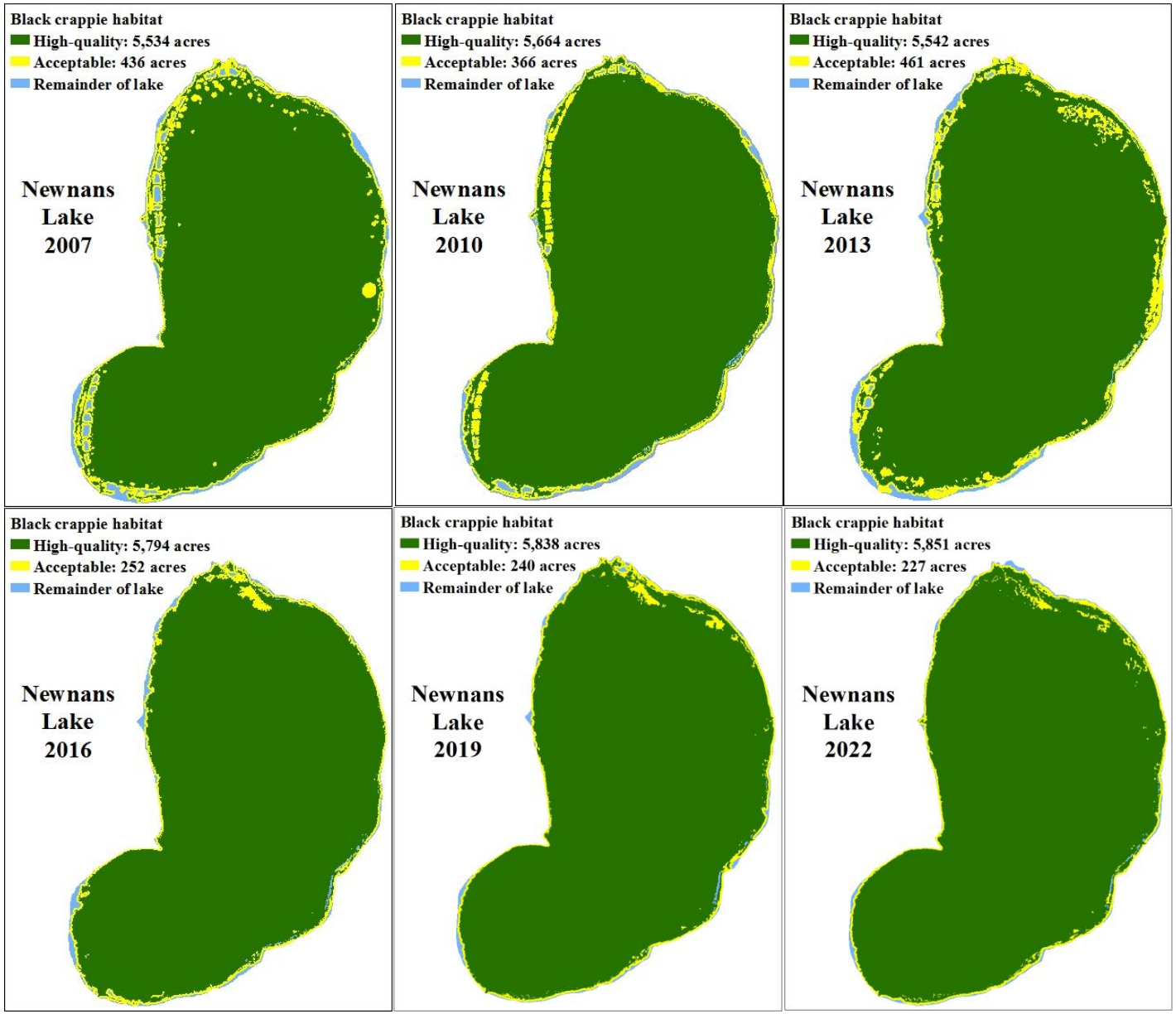

Figure F 10. Location of black crappie habitat identified with GIS analysis of vegetation maps on Newnans Lake from 2007 to 2022.

Table F 10. Area (acres) of high-quality and acceptable habitat per habitat type for largemouth bass in Newnans Lake, based on GIS analysis of vegetation maps produced from 2007 to 2022.

Newnans Lake	Largemouth bass					
Habitat type	**2007**	**2010**	**2013**	**2016**	**2019**	**2022**
High-quality habitat						
Open water	193	47	94	45	131	154
Hardwood swamp						
Tree island						
Willow shrub swamp						
Complex floating marsh						
Tall linear-leaved shallow marsh	8	4	7	3	10	8
Maidencane shallow marsh						
Mixed shrub swamp						
Flag shallow marsh						
Grass deep marsh			2	1	3	3
Low floating marsh						
Mixed shallow marsh						
Floating island						
Floating-leaved deep marsh	71	11	208	12	35	38
Submersed aquatic vegetation	11	<1	4			
Sub-total high-quality habitat	**282**	**62**	**315**	**62**	**179**	**203**
Acceptable habitat						
Open water	339	303	426	285	274	251
Hardwood swamp						
Tree island		<1			<1	<1
Willow shrub swamp	46	55	19	5	6	1
Complex floating marsh	10	10	28	4	<1	1
Tall linear-leaved shallow marsh	<1	<1	4	<1	3	1
Maidencane shallow marsh	<1	1	1	3		
Mixed shrub swamp	79	39	11	16	8	4
Flag shallow marsh	3	31				
Grass deep marsh				1	1	<1
Low floating marsh	79	69	102	41	25	16
Mixed shallow marsh	8	5	4	<1	<1	
Floating island		<1	3	2	<1	
Floating-leaved deep marsh	22	8	134	125	40	25
Submersed aquatic vegetation	3		4			
Sub-total acceptable habitat	**589**	**522**	**734**	**482**	**356**	**299**
Total habitat	**871**	**584**	**1,049**	**544**	**536**	**502**

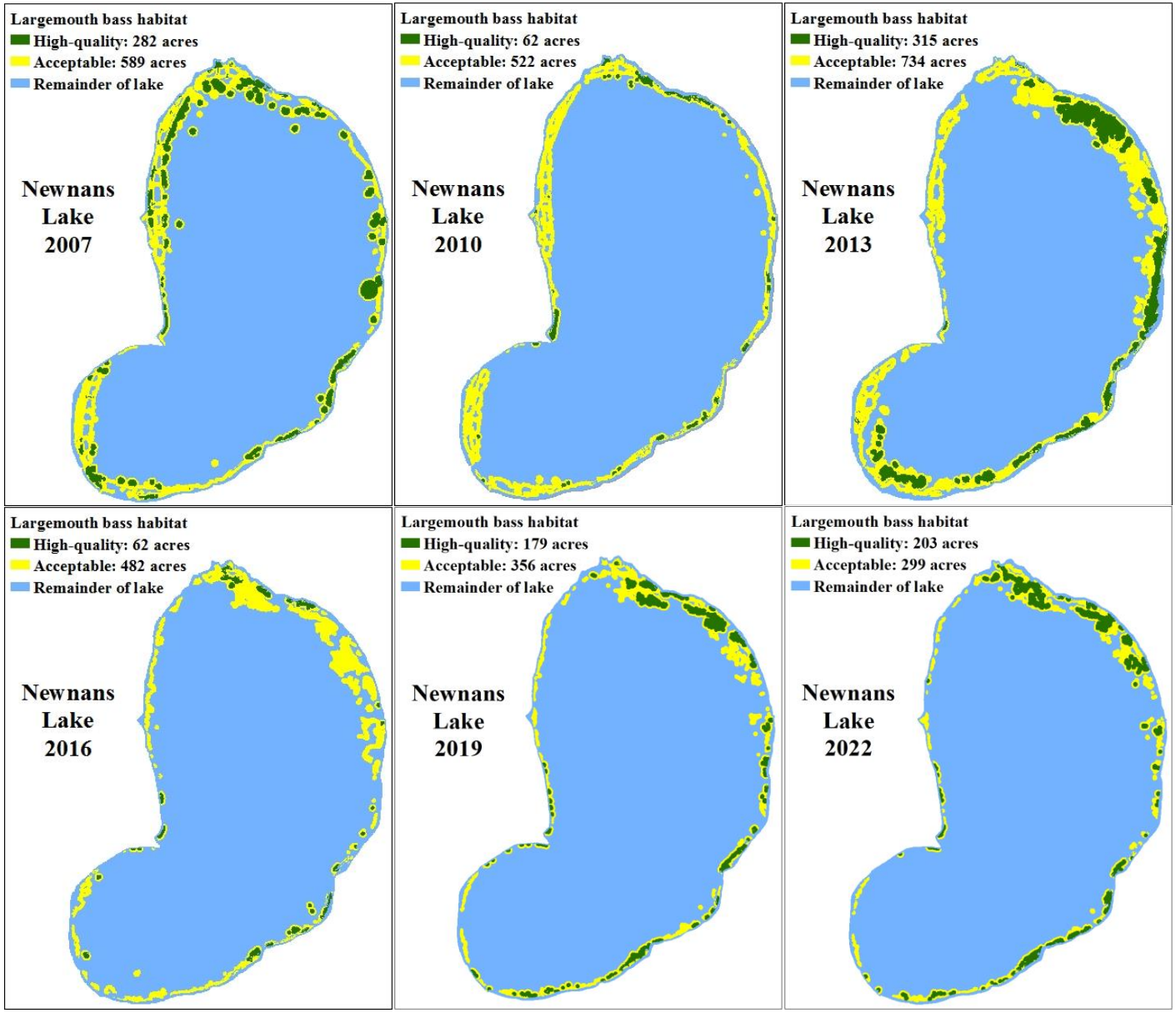

Figure F 11. Location of largemouth bass habitat identified with GIS analysis of vegetation maps on Newnans Lake from 2007 to 2022.