Wildlife Habitat Relations of the Everglades Agricultural Area, Florida

A Final Report
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EXECUTIVE SUMMARY

In a three year study of wildlife habitat relations in the Everglades Agricultural Area (EAA) near Belle Glade, Florida we studied the distribution and habitat affinities of vertebrate species in agricultural fields. The EAA is planted mostly in sugarcane (about 90%) but also supports rice fields, vegetables and sod. Agricultural fields are organized around a system of canals and ditches that provide irrigation and allow for flooding of rice and fallow fields. Field edges are left brushy or may be sprayed or mowed to control vegetation. There are very few trees in the agricultural fields themselves but some in the vicinity of outbuildings and houses. The purpose of the study was to determine wildlife habitat relations, diversity and abundance in the EAA, to assess effects of habitat management and to produce educational material regarding wildlife in the EAA.

We surveyed fish, anurans (frogs and toads), and birds in standardized, repeatable surveys of sugarcane, rice and fallow fields. Our observations of reptiles and mammals were incidental as we conducted other surveys and drove to and from study sites in the area. We conducted similar surveys of the same taxa in the impoundments of Arthur R. Marshall Loxahatchee National Wildlife Refuge for purposes of comparison. Rice field surveys lasted two years and sugarcane surveys for two years and they overlapped for one year.

Our surveys found significantly more bird individuals in agricultural fields than in non-agricultural impoundments. There were an equal number of fish in agricultural and impoundment and fewer anurans in agriculture than impoundments. Although we could not statistically test for differences we observed more individual reptiles and mammals in agriculture than in impoundments.

We observed more species of every taxon in agricultural areas than in impoundments. These included animals that are wetland dependent as well as those that occupy upland habitat. Many animal species utilized edges between agricultural fields and canals or ditches. We did not observe a greater number of exotic species in agriculture than in impoundments. There were no noticeable negative impacts of cultivation practices on animal populations.

Agricultural habitat of the EAA is large in scale, of fairly low input and contains an abundance of edge and aquatic habitat that supports a large population of diverse wildlife. When compared with impoundments at LOX that are managed for wildlife we found that wildlife is generally more abundant and species rich in the EAA although diversity did not appear to be different between the two habitats. Management of the EAA, although directed towards agricultural yield, supports extensive wildlife habitat. Our goal is to provide information that will assist managers in maintaining and improving wildlife habitat in conjunction with agricultural operations.

INTRODUCTION

Agricultural lands have potential to be important habitat for wildlife. Throughout much of the United States wildlife managers cooperate closely with agricultural interests to develop sustainable farming operations that contribute to the conservation of biological diversity (Pimentel *et al.* 1992). Opportunities for cooperation exist in the Everglades Agricultural Area (EAA), but have not previously been explored. Some studies have quantified wildlife use of agricultural fields or related habitat conditions or agricultural management practices to diversity or abundance of wildlife (Best *et al.* 1990; Bignal and McCracken 1996; Czech and Parsons 2002; Fujioka *et al.* 2001; Hazell *et al.* 2001; Leptich 1994). However, there is little data available to develop specific management practices for wildlife in agricultural fields in Florida. There is also little specific information available to assist decision makers, the conservation community, or the general public.

Aside from the documented presence of prominent species of water birds (Lodge and Clark 1996; Pimentel *et al.* 1992; Townsend 2000) little has been known about wildlife in the EAA and there is a perception that the area lacks significant wildlife resources or that the area is a hazard to wildlife. Efforts at restoring wildlife populations as part of the restoration of Greater Everglades ecosystems have concentrated on the remaining natural areas in the Everglades region. However, the use of the EAA as a foraging area for wading birds, a rest stop for migratory birds, and as habitat supporting complete life cycles of several species, combined with its size and the strategic location between Lake Okeechobee and the Water Conservation Areas, make the EAA an important component of a South Florida landscape that is both economically and ecologically sustainable. This project was originated to provide a scientific basis for increasing the understanding of the wildlife and ecological values of the EAA.

The goals and objectives of this study were to:

1. Determine habitat relations of wildlife in the EAA.
2. Evaluate the effects of selected agricultural practices on wildlife populations, for example:
    - Flooded vs fallow summer fields.
    - Impacts of fire on reptiles and small mammals in cane fields.
    - Aquatic prey populations and drawdowns in rice fields.
    - Impacts of canal and ditch management of aquatic organisms.
    - Exposure of wildlife to contaminants.
3. Develop an education program for growers, restoration officials, conservationists, and the general public as to the role the EAA in the conserving biological diversity of Greater Everglades/South Florida wildlife.

STUDY AREA

The Everglades Agricultural Area (EAA) covers an area of 280,000 ha in southern Florida surrounding the southern end of Lake Okeechobee. It occupies former marsh habitat that was drained beginning at the turn of the century. Installation of water control structures and pump stations allowed for formation of the EAA in the middle of the last century (Light and Dineen 1994). This resulted in a great increase in sugar production. Agricultural activities occur on approximately 200,000 ha of the EAA with sugarcane representing about 80% of land use. Rice was first harvested as grain in 1977 in rotation with sugarcane during the fallow period (Alvarez and Snyder 2004). Rice, vegetables and sod are also grown in much smaller quantities on the remaining land (Izuno *et al.* 1991). In 2002, production of sugarcane ranked first in the nation at 51% with cash receipts worth $518 million (Florida Department of Agriculture and Consumer Services 2004).

The EAA is located in southern Florida in the midst of natural areas such as Holey Land and Rotenberger Wildlife Refuges, Arthur R. Marshall Loxahatchee National Wildlife Refuge (LOX), Everglades National Park, Big Cypress National Park and a number of state water management areas. Extensive reclamation efforts in natural habitat of the Everglades and South Florida have resulted in scientific studies of hydrology, ecology and natural history of the animal and plants that inhabit the area (Davis and Ogden 1994). Highly urbanized areas cover much of the land to the east of the EAA and, like most urban habitat (Blair 1996), these areas may have lower species richness and diversity as well as high numbers of non-native species.

Crops are grown on former Everglades marsh characterized by peat and muck soils (Rice et al. 2002). Associated with these agricultural activities are miles of canals and ditches, and acres of associated non-agricultural edge habitat. Canals are dug into the limestone where they are fed by groundwater and tend to retain water throughout the year. Ditches are characterized by temporary flooding in response to particular crop needs. Non-agricultural vegetation grows at the edges of fields, ditches and canals. Edge vegetation may be herbaceous or brushy and is usually non-native.

Agricultural activities are thought to fragment and simplify habitat, decrease the number of native species, increase the presence of exotic species, and potentially contribute to an increase in pollutants (Freemark 1995). However, crops such as rice may provide important habitat for many of the world's waterbirds especially herons and egrets (Elphick 2000; Fasola and Ruiz 1996; Kushlan and Hafner 2000; Maeda 2001; Tourenq *et al.* 2001), but Tourenq *et al.* (2001) emphasize that they are not always equivalent to natural marsh habitat. Edge habitat in many types of agricultural crops may support a diversity of wildlife (Best *et al.* 1990) and is considered to be an important component of agricultural operations. Fallow, especially flooded fallow, fields are also important for a number of bird species (Elphick and Oring 2003; Fujioka *et al.* 2001; Sykes and Hunter 1978).

We conducted extensive and intensive surveys in both rice fields and sugarcane fields along with associated ditches, canals and edge habitat. These were to document wildlife habitat use. We also conducted surveys for certain taxa; these included a roadside raptor survey and a survey of reptiles and amphibians. These surveys are discussed in the sections below.

WILDLIFE HABITAT USE

Rice fields

Methods: We chose rice fields with differences in management and construction such as edge vegetation, dike or berm construction and canal and ditch layout. Road accessibility also affected the study areas chosen. Each rice field consisted of 8 to 10 units separated by ditches. Ditches and internal units were chosen randomly within each larger rice field. Different management type fields were chosen with two replicates in each for a total of 14 fields, two of which were organically grown. Management differences included edge maintenance and water management as well as general field maintenance. The study began just before the rice fields were flooded and ended as they were drained for harvest. Once the rice field is flooded with approximately 30 cm of water, pumping ceases and the fields remain flooded until a week or ten days before harvest, 80-90 days later. Surveys of fallow and fallow flooded fields followed the same protocol as for rice fields.

We used two different live traps, minnow traps of 1/8" mesh size and Breder traps for our fish surveys. If a ditch or canal was inaccessible for setting minnow traps, a second choice was randomly selected. Minnow traps were set in the canals and ditches a week before flooding, after the rice had been planted and begun to sprout. Both minnow and Breder traps were then set after fields were flooded. Un-baited minnow traps were placed at dusk for overnight surveys. In the early morning both Breder and minnow traps were set for 20 minutes. Breder traps were not left out overnight because it is difficult to assure the availability of oxygen in the enclosed plexiglass body of the traps. Minnow and Breder traps were set side by side in three different spots per field, at the ditch, edge, and mid-field within rice, only minnow traps were used in canals. We weren't able to use Breder traps in canals due to steep sides and the potential for swifter currents that would sweep them away. Both traps were near the waters edge and filled half way with water to allow other aquatic species air to breathe if caught in the traps during the survey. Visual surveys were also conducted in deeper canals for larger fish. All fish and invertebrates caught from each trap were identified to species, sexed and aged where possible and counted making note of any deformities or abnormalities and then released.

Bird surveys were conducted during mid-morning when birds were actively foraging. The observation area included one rice field unit and the ditches, dikes and canals directly associated with it. One edge of a field unit was walked and birds were counted for a period of ten minutes. All birds seen or heard in each field were noted. For each species we recorded the number of individuals observed, age, sex, location in the field and activity. Sex and age were determined, if possible, by observing differences in plumage. Breeding plumage, if present, was recorded. Birds flying over the field were also recorded.

Sugarcane
Methods: Fourteen sugarcane fields were chosen based on different ownership and management and based on accessibility. We chose roads that were driveable but had low traffic volume. A road transect was determined with four to six stopping points on each that included stops at ditches within the fields. We censused fish in canals and ditches using the same methods as in rice, but did not use Breder traps. Call count surveys for frogs and toads (anurans) were conducted in the evenings just after sunset. Any calling anurans were identified to species and assigned a number from 1-5 representing abundance from single individuals to large choruses. Bird surveys began within an hour after sunrise. Point counts were conducted for 5 minutes at each point. All birds seen or heard were recorded, including those flying over. The number of individuals observed, age, sex, location and activity were also recorded for each species. Searches of the area were also conducted to find silent individuals as well as to locate mammals or other animals hidden in the vegetation of ditches and fields.

Non-agricultural Habitat
Methods: We conducted surveys with identical protocols in the impoundments of the Arthur R. Marshall Loxahatchee National Wildlife Refuge (LOX) to compare with surveys in agriculture. The survey areas included impoundments in the refuge that are managed for wildlife and are similar in composition and layout to the agricultural fields. Each impoundment consists of a flooded area with a deeper ditch and/or canal and adjacent road. Surveys in impoundments were designed to replicate the surveys we conducted in both rice and sugarcane.

Raptor Surveys
Methods: We conducted roadside raptor surveys along SR 27 from the Palm Beach county border to Belle Glade just south of Lake Okeechobee. Raptors were observed, a location was plotted using a GPS, and specific habitat data was recorded including habitat type and perch type selection. Density along the roadside as well as species richness and diversity in each habitat type was calculated. Observations on this survey represent the majority of raptor sightings but we also included raptors seen during other surveys. Owls were generally sighted during our dawn and dusk surveys in sugarcane fields.

Intensive Amphibian and Reptile Surveys
Methods: We spent one week in March 2003 and March 2004 surveying a number of sugarcane fields for reptile and amphibian species occurrences. There were 15 people involved from several different organizations. The surveys were organized within and around sugarcane fields during and after harvest and followed ditches and canals associated with these fields. All volunteers walked one edge of a ditch/canal and caught or observed any amphibians or reptiles they encountered. All snakes were identified to species and sex and were measured where possible. All other observations were also identified to species and recorded. Photos and GPS locations were taken of all Florida Kingsnakes (*Lampropeltis getula floridana*) and other unusual observations.

Analysis
Significant differences in counts of individuals were determined using a Mann-Whitney Rank Sum Test (SigmaStat3.0, SPSS Inc., Chicago, IL) because the count data did not have a normal distribution. We analyzed differences for individual fish, birds and anurans only because those counts were systematic and repeatable. Units of measure for fish were unit trap effort and for anurans a rank of individual or chorus counts per census site. For birds we used number of birds per count effort in the rice field and sugarcane surveys. We did not test for significant differences in numbers of reptiles and mammals but describe patterns.

Diversity indices were calculated using Simpson's index and the Shannon-Wiener index. Both of these take into account both number of species and number of individuals within a species. Simpson's index quantifies diversity by providing the likelihood that two animals encountered will be of different species. A higher number indicates a higher likelihood that animals will be of different species, thus the more diverse the community. The Shannon-Wiener index is a measure of uncertainty. Maximum diversity yields maximum uncertainty; the higher the index, the higher the uncertainty. There were no obvious differences in diversity in different animal groups in different fields compared with impoundments (Table 1).

No tests were possible for number of species in each taxon in the different habitats. We simply describe patterns of species richness for each habitat.

RESULTS AND DISCUSSION

General
There was no significant difference in number of individual fish in agricultural habitat and impoundment. Anurans were more abundant in non-agricultural habitat than in agriculture (Mann-Whitney Rank Sum Test, $p < 0.001$). Birds were significantly more abundant in agricultural habitat than in impoundments (Mann-Whitney Rank Sum Test, $p < 0.001$). Numbers of individual mammals and reptiles couldn't be tested because of survey design. There were more species of all taxonomic groups in agricultural than in non-agricultural habitat (Table 1).

Sugarcane:
Individuals: Fish were equally abundant in impoundment and sugarcane (Mann-Whitney Rank Sum Test $P > 0.01$). Anurans were more abundant in impoundments than in sugarcane (Mann-Whitney Rank Sum Test $P < 0.001$) and birds were more abundant in sugarcane than in impoundment (Mann-Whitney Rank Sum Test $P < 0.001$) (Table 1).
Species: The habitat directly within sugarcane fields as well as associated ditches, canals and edges supports the highest number of bird species of all agricultural areas. It also supports a higher number of fish, anuran, reptile, and mammal species than impoundments (Table 2).

Rice:
Individuals: There were significantly more fish in rice fields than sugarcane and impoundments (Mann-Whitney Rank Sum Test, $p < 0.001$). There were significantly more birds occurring in rice than in impoundments (Mann-Whitney Rank Sum Test $P < 0.001$) (Table 1).
Species: There were more species of fish occurring in rice than in impoundments and an equal number to those occurring in sugarcane. The number of bird species found in rice fields was less than those occurring in sugarcane or impoundments. Amphibians, reptiles and mammals were not surveyed for in rice.

Fallow and Flooded/Fallow fields:
Individuals: There were more birds observed in fallow and flooded/fallow than in impoundments (Mann-Whitney Rank Sum Test, $p<0.01$) but no significant differences between fallow and flooded/fallow and other agricultural field types (Table 1).
Species: Birds only were counted in these fields and we found a higher number of species in fallow, flooded/fallow fields than in rice but fewer than in sugarcane or impoundments (Table 1).

Table 1. Numbers of individuals (I), species (S) and diversity measures (D, Simpson's diversity is the first number, Shannon-Wiener is the second) for each field type.

Taxon	**Agriculture**	**Sugarcane**	**Rice**	**Fallow**	**Impoundment**
Fish	I: 8.49 S: 21(7) D: 0.40/0.39	I: 5.15 S: 19(6) D: 0.5/0.5	I: 12.17 S: 19(4) D: 0.3/0.3		I: 6.07 S: 14(3) D: 0.37/0.38
Birds	I: 4.99 S: 98(3) D: 0.9/1.3	I: 4.38 S: 72(2) D: 0.8/1.0	I: 5.23 S: 56(1) D: 0.9/1.3	I: 6.5-7.0 S: 61(1)	I: 3.32 S: 63(3) D: 0.9/1.4

Table 2. Number of species found in agriculture and impoundment.

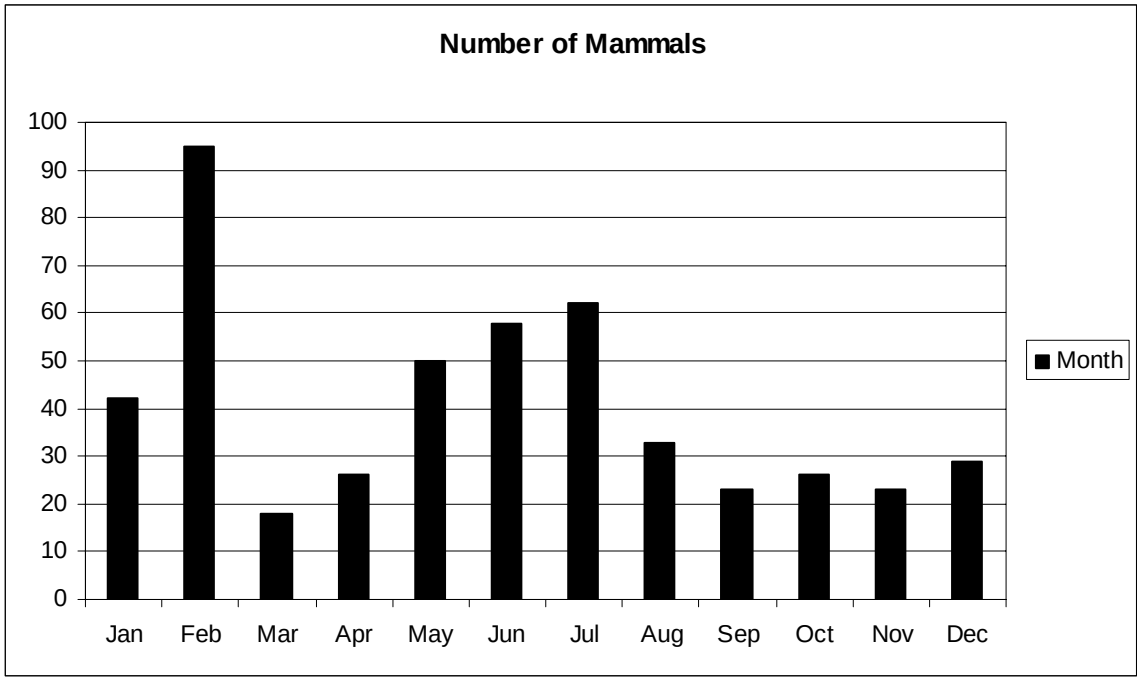
Taxon	**Agriculture**	**Impoundment**
Anurans	S: 13(3)	S: 11(2)
Reptiles	S: 22(1)	S: 8(1)
Mammals	S: 12(2)	S: 6(1)

General Patterns:
We observed more individuals, on average, of all taxa except amphibians in the EAA than in impoundments at LOX; fish and birds were statistically more abundant in at least some habitats in the EAA than in LOX. The only taxon in which individuals were less abundant in the EAA than at LOX was the anurans (frogs and toads). All agricultural types had more species than those at LOX and diversity of all types was not apparently different within each taxon.

Sugarcane habitat supports a diverse and abundant population of animals that use fields, edges, ditches and canals of sugarcane. The highest number of bird species was found in our sugarcane surveys with upland and grassland bird species contributing to those numbers. Both mammals and reptiles also utilize the sugarcane fields in high numbers. Although we were unable to test the numbers statistically, the pattern seemed clear that more reptiles and mammals were found in sugarcane than impoundment habitat. Anurans were specifically surveyed for in sugarcane and individuals were less abundant in sugarcane than in impoundment.

Large numbers of Eastern Cottontail (*Sylvilagus floridanus*) and Marsh Rabbits (*S. palustris*) utilize sugarcane fields and nearby areas. These two species seem to thrive in the agricultural habitat found in the EAA and are minimally impacted by cultivation practices that occur in the winter and early spring each year (Figure 1). Mammals such as the River Otter (*Lutra canadensis*) utilize the water associated with sugarcane fields as well. Bobcats (*Lynx rufus*) were also frequently seen hunting in cane fields and along canals. Numbers of mammals exhibit with a peak in February that may represent increased visibility in the harvested sugarcane fields (Figure 1). Reproduction may be more successful in the spring and summer months resulting in another peak in numbers.

Figure 1. Total number of mammals observed by month.



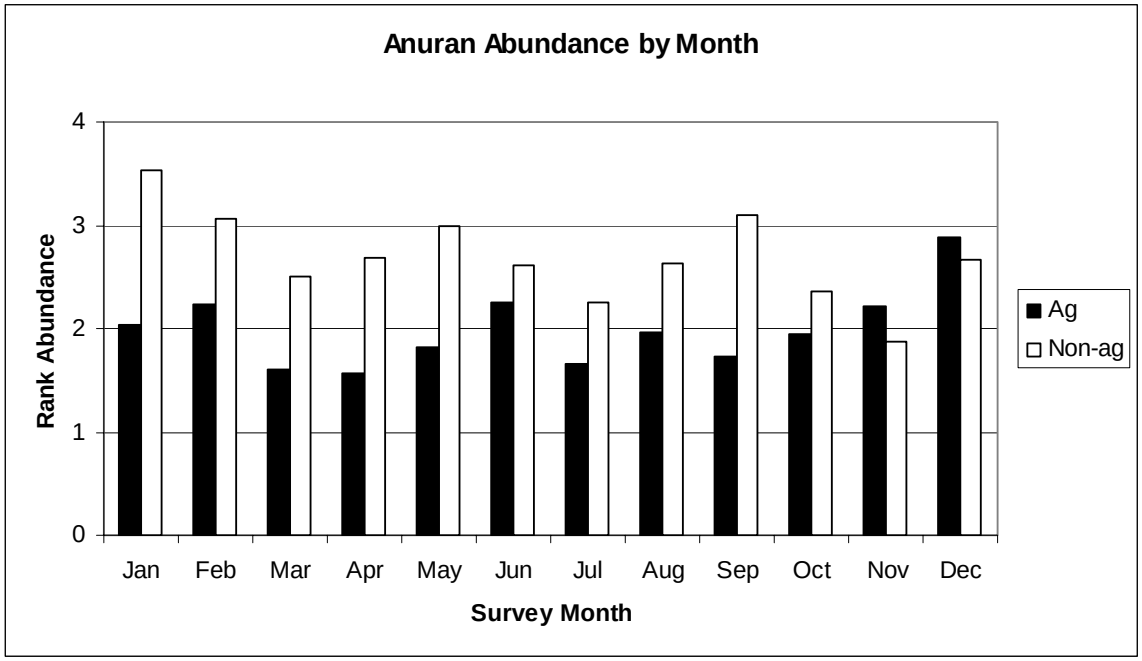
Sugarcane fields themselves probably do not provide primary habitat for the majority of the animals found there but animals are utilizing adjacent fields, field edges, ditches and canals in conjunction with the sugarcane itself. Within sugarcane fields, birds that were commonly found were species such as Common Yellowthroat (*Geothylpis trichas*), Red-winged Blackbird (*Agelaius phoeniceus*) and Boat-tailed Grackle (*Quiscalus niger*). We

also observed Northern Bobwhite (*Colinus virginianus*) during our sugarcane surveys as well as raptor species such as the Northern Harrier (*Circus cyaneus*). A large number of Northern Harriers make use of the sugarcane fields for hunting during the winter. Red-tailed Hawks (*Buteo jamaicensis*) and American Kestrels (*Falco sparverius*) were much more abundant along roadsides near sugarcane fields than in natural habitat nearby. One fallow sugarcane field supported a family of Sandhill Cranes (*Grus canadensis*) during the summer of 2003. Doves and swallows frequented habitat adjacent to and above sugarcane fields; swallows were especially abundant during migration as they hawked for insects above the fields. Various waterbirds and ducks were commonly found in canals and ditches in the fields.

Reptiles are fairly common throughout the EAA but areas associated with sugarcane fields seem to provide especially good habitat for some species. Snakes are especially common in this habitat. Numbers of the Florida Kingsnake (*Lampropeltis getula floridana*) have declined in recent years due to habitat loss (Krysko 2002) and it is thought that agricultural ditches and canals provide good habitat for individuals in south Florida. Frogs and toads were less abundant in sugarcane than in impoundments (Figure 2), however we observed more species in sugarcane fields. Lower numbers of anurans may result from a combination of agricultural practices such as the use of pesticides and the configuration and management of ditches and canals. While the effects of pesticides are unknown in the EAA, we observed a number of ditches and canals to dry up periodically. This seemed to affect some species like the Pig Frog (*Rana gryllio*) that need permanent water to reproduce. Other species prefer temporary wetlands that are free of fish and other tadpole predators. Although the drying of canals and ditches may be thought of as providing similar habitat to temporary wetlands, they provide ready access for fish as soon as they are re-flooded, unlike ephemeral ponds. In addition, straight edges of the canals and ditches provide little in the way of shallow eddies where tadpoles might find refuge from predators.

Rice fields in the EAA, and worldwide, may function as man-made wetlands and are considered to be important habitat for waterbirds, especially herons, in many parts of the world (Elphick 2000; Fasola *et al.* 1996; Kushlan and Hafner 2000; Tourenq *et al.* 2001). We found this to be true in the EAA but most birds seemed to be individuals that were dispersing from natural Everglades habitat. The larger birds such as Wood Storks (*Mycteria americana*) and Great Egrets (*Ardea alba*) as well as numerous small herons and egrets were especially attracted to the rice fields as they were being drained for harvesting. This accounts in part for the much larger numbers of birds in the EAA during the summer and fall (Figure 3).

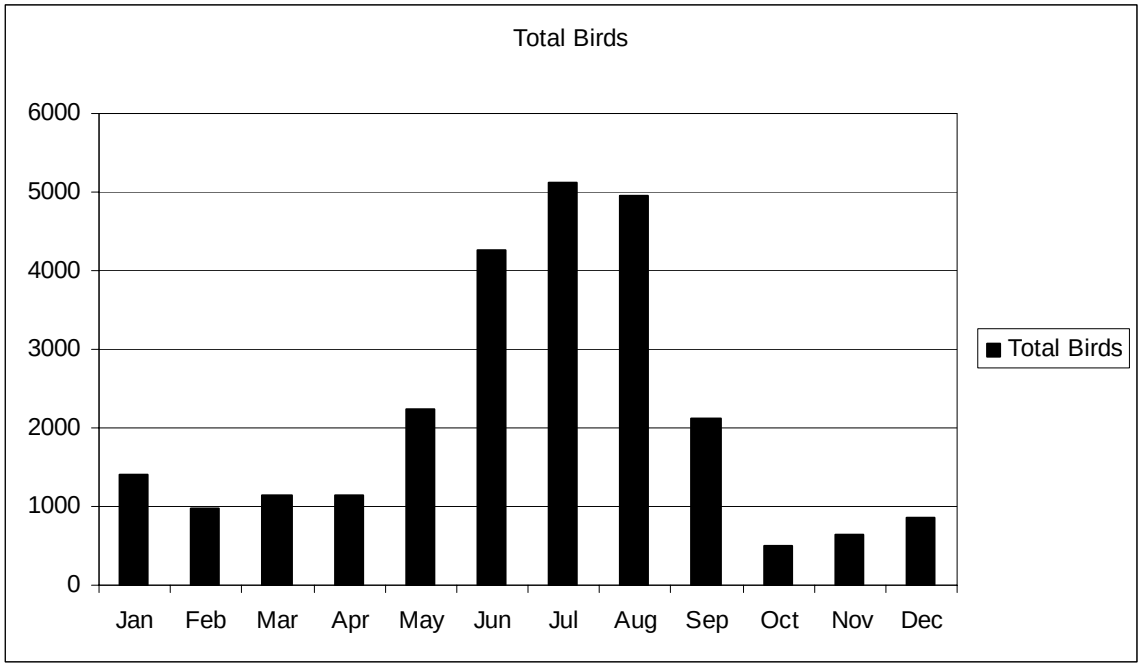
Figure 2. Numbers of anurans by month in agricultural and non-agricultural habitat.



Some birds were observed to breed in the rice fields including Least Bitterns (*Ixybrychus exilis*), Purple Gallinules (*Porphyrio martinica*), Common Moorhens (*Gallinula chloropus*) and King Rails (*Rallus elegans*). Mottled Ducks (*Anas fulvigula*), Black-bellied Whistling-Ducks (*Dendrocygna autumnalis*) and Fulvous Whistling-Ducks (*D. bicolor*) are also probably breeding in the rice fields. For these birds the timing of the rice planting and the structure of the rice paddies provide appropriate nesting and foraging habitat.

Some components necessary for breeding are missing for many other water dependent birds. There are few trees that would be appropriate for rookeries for larger birds. Additionally, rice fields are usually planted in between March and May which may be too late for common species to establish nests. Most of these birds tend to form colonies in November-January (Wood Storks) and February through March (small herons, egrets and ibis) during normal water level years (Ogden 1994) although some species will nest later in unusual water years. This means that they are forming colonies before rice fields exist and thus cannot use these areas for nesting. However, when the wet season begins and natural nesting habitat is under deeper water it appears that many adult and fledgling birds use rice fields as foraging habitat. Figure 2 illustrates the timing of movement of birds into the EAA beginning in the spring.

Figure 3. Bird abundance by month in the EAA.



Fish were present and sometimes abundant in the canals and ditches surrounding the rice fields and were present in the fields themselves virtually as soon as the fields were flooded. These were smaller species such as Eastern Mosquitofish (*Gambusia holbrooki*), Flagfish (*Jordanella floridae*), Bluefin Killifish (*Lucania goodei*) and Least Killifish (*Heterandria formosa*) as well as juveniles of some larger species. These fish are capable of reproducing quickly to populate the flooded fields (Loftus and Eklund 1994) and were able to take advantage of the newly flooded habitat. After 80 days population growth in flooded rice fields, they filled the ditches and canals during drawdown, providing ample forage for waterbirds.

While we did not specifically survey for other animals besides fish and birds, we observed many of the animals listed as present in the EAA in or adjacent to rice fields. Fallow and fallow/flooded fields are important habitat in the EAA for waterbirds and migratory shorebirds. Bird abundance is high in these areas during late summer and fall reflecting the large numbers of migratory shorebirds present at this time (Figure 2).

Ditches and canals are present throughout the EAA and provide connectivity between fields and with natural habitat adjacent to the EAA. They also provide important aquatic habitat for many of the animals in the agricultural fields. Other than strictly aquatic animals such as fish, anurans, river otters and turtles, there are watersnakes and other snake species that utilize ditch and canal edges for foraging. Waterbirds and songbirds feed in or near the water and use edge vegetation for roosting. Bobcats were observed using the cleared edges of canals as they moved from fields to field and mammal signs were common along ditch and canal banks.

Contrary to general expectations for agricultural systems, there did not seem to be a higher number of non-native species compared with other south Florida habitats. While they were present, they did not outnumber native species nor comprise a significant portion of the species diversity. We found numerous Brown Anoles and geckos but those were generally around buildings in the Belle Glade area. Occurrence of Cuban Tree Frogs (*Osteopilus septentrionalis*) in fields is spotty; they are found regularly in some areas and not at all in others. Few species of non-native birds have been found in the EAA but, like the reptiles and amphibians, more may occur near towns and buildings. Fish populations had the largest percentage of non-native species with up to 33 percent of the species caught or observed being non-native.

CHARACTERISTICS OF AGRICULTURE IN THE EAA

The EAA as an agricultural system provides an array of benefits as well as challenges to the wildlife that live there.

Benefits:

1. Nutrient input increases growth of crops and probably provides benefits for edge and other vegetation as well.
2. Cultivation of crops – A number of animal species benefit from cultivation of crops such as rice. This is probably the most important wildlife crop in the EAA because it provides wetland habitat for a large number of birds and fish. Cultivation of sugarcane and other crops are beneficial to animals that forage in these crops, that follow machinery during planting and harvest, and that prey on animals that live in these fields.
3. The size of the EAA is such that even unplanted areas such as canals, ditches, non-agricultural areas and edges provide a large amount of habitat for a variety of wildlife.
4. Most of the boundary of the EAA is adjacent to natural landscapes or reclaimed wetlands such as the Water Conservation Areas. Animals from these localities may find dispersal or migratory habitat in the EAA.
5. Agricultural fields of the EAA are extensive and are accessed by unpaved roads that are usually gated. This limits access to most of the area and provides habitat that is relatively undisturbed by human use.
6. Flooded fields of the EAA provide surrogate wetland habitat for many birds and other animals. Canals and ditches are also important for aquatic animals.
7. The ability to manage water flow and flooding of the fields is an opportunity to provide for the benefit of wildlife.
8. Sugarcane and rice are both fairly low input agricultural crops. While fertilizer and pesticide application is definitely a concern, these crops are preferable to many other types. A small percentage of the EAA is cultivated in higher input crops such as vegetables and sod.
9. The presence of managers on the EAA limits the possibility of human disturbances such as hunting, harassment, collecting for pets, and littering/polluting.

Challenges presented by habitat in the EAA are generally related to agricultural practices and may be, in some cases, the same as the benefits.

Challenges:

1. While nutrient input is relatively low for agriculture, it is still an alteration of the natural Everglades system and has undoubtedly resulted in artificial habitat and encouraged the proliferation of weedy and non-native species of plants.
2. Cultivation of agricultural crops carries with it a set of intrinsic dangers to wildlife. The use of machinery is a disturbance and is often fatal to animals that inhabit and breed in the fields. Heavy machinery compacts soil, plowing and sowing disturb soil and may contribute to erosion. Harvesting, especially using fire, is a high disturbance period in the cultivation cycle. Yearly growth and plowing cycles are detrimental to some species such as Round-tailed Muskrat that require longer periods of stable habitat.
3. The application of chemicals such as herbicides is not desirable in areas where animals are feeding and reproducing. Pesticides can cause mortality, developmental abnormalities, reproductive disturbances, and low recruitment.
4. Decisions relating to water management have as their first priority the benefit of crops. Thus, water may be withdrawn from fields at a critical point in the reproductive or migratory cycle of animals that are dependent on aquatic habitat. Flooding and drying of fields is also out of sync with natural wetlands in the area.
5. Crop type and rotation decisions are made with economic basis, not wildlife. The fluctuating price of rice determines the amount of habitat available for wetland nesting and dispersing birds.
6. Fire control, management styles and control of weedy plants contribute to the clearing of brushy habitat on the edges of fields and ditches. It probably also discourages the growth of trees on upland habitat. The absence of trees in natural clumps and groups does not allow for roosting and breeding of many tree or woodland/forest dependent species.
7. Agricultural operations and associated built areas support common species and non-native species. These systems are less complex and incapable of supporting rare or sensitive species. They are also fragmented and generally disturbed.

Attributes

1. Agricultural fields of the EAA are large and extensive in area. Sugarcane is essentially undisturbed for nearly a year between harvest activities and covers hundreds of thousands of acres. Rice is present throughout three to six months of the spring and summer and covers thousands of acres. Row crops are present on a small percentage of land in rotation with sugarcane or rice. Sod is generally grown in the same fields year after year on a low number of acres.
2. Ditches and canals intersect and connect all habitats of the EAA. They are continuous with Lake Okeechobee to the north and Everglades to the south. Large canals are flooded throughout the year, smaller canals and ditches generally

experience a lowering of water level or complete drydown during the year. Management consists of dredging and removal of aquatic vegetation.

3. There is little urbanized habitat within the EAA itself. Farm buildings, barns and pump houses dot the landscape. The towns of Belle Glade and South Bay are located on the south end of Lake Okeechobee and Clewiston is to the north and west of these.
4. The landscape of the EAA is changing and dynamic, characterized by growing and harvest of crops, plowing and tilling of the land, burning of sugarcane, rotation of crops and flooding and drying of some fields and ditches.
5. Upland and wetland habitat exist in close proximity to each other. Upland habitat is characterized by narrow strips of mostly non-native species that are found on the edges of fields and along ditches and canals. The vegetation is usually brushy or herbaceous. Wetland habitat is usually associated with rice cultivation or flooding of fallow fields and is connected by a network of ditches and canals.

Linkages

1. Wet and flooded fields provide dispersal habitat for waterbirds from adjacent natural habitat in the Everglades, stormwater treatment areas, LOX, Holeyland and Rotenberger Wildlife Management Areas.
2. Edge and upland may provide corridors and temporary habitat for larger animals moving from southwest Florida to the east. Areas to the southwest include Big Cypress, Panther Habitat and Fakahatchee Strand.
3. Large canals connect Lake Okeechobee to the north with the Everglades to the south.
4. Ditches, canals and flooded fields that are adjacent to sugarcane or upland edges provide an upland/wetland interface.

Unknowns

1. It is unknown whether the EAA provides source or sink for breeding animals.
2. What are the effects of pesticides?
3. What are the effects of timing and hydroperiod in rice and flooded fallow as well as canal drying and maintenance?

MANAGEMENT RECOMMENDATIONS ARISING FROM THE CURRENT STUDY

Wherever possible we recommend that managers maximize the attractiveness of edge and uncultivated fields for wildlife. Leaving edges unmowed and untreated while allowing brushy vegetation to grow encourages a variety of wildlife. Many species using these edge habitats may be predators of agricultural pests such as rodents and small mammals in sugarcane fields. Herbaceous and brushy growth on the edges of canals also decreases runoff from the fields into these water bodies.

Where there are larger areas of edge or upland that are not in cultivation we recommend planting native trees and plants for the benefit of wildlife.

Water in ditches and in the fields is also a significant habitat for wildlife. Wherever possible, in keeping with overall water management needs, fields should be flooded and rice should be grown where appropriate. It is also desirable to keep water in as many ditches and small canals as possible throughout the year.

We encourage continued limited use of chemical fertilizers and pesticides with the investigation into alternative practices to further limit use of these chemicals.

We believe that limited access to the fields has had benefits for a number of wildlife species, especially those that are sensitive to disturbance such as nesting birds and those that may be collected for the pet trade such as the Florida Kingsnake. Our experience has been that access is controlled and that managers are very aware of activities in their fields. We encourage the continuation of this practice, especially in the springtime when animals are breeding.

Many of the mammal species that are found in or adjacent to sugarcane fields may benefit from longer rotations in some fields and from lower intensity harvesting activities. We encourage this in fields where economical and management considerations allow.

We recognize that not all these suggestions are economically or practically feasible and yet we hope that managers and owners who value wildlife on their property will find a way to incorporate at least some of them into their management strategies. While agricultural operations cease to exist if they do not prove profitable, they are also a part of the greater landscape and of a local culture in which wildlife is intrinsically valuable. Therefore, we hope that our studies have had and will continue to have practical application for the benefit of wildlife in the EAA.

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Table 3. Species of fish and number of times observed in rice and sugarcane fields.

Fish Species	Total
Armored Catfish	29
Black Acara	14
Blue Tilapia	3
Bluefin Killifish	377
Bluegill Sunfish	175
Bluespotted Sunfish	31
Brook Silverside	13
Brown Bullhead	11
Brown Hoplo	2
Dollar Sunfish	7
Eastern Mosquitofish	14686
Flagfish	860
Florida Gar	20
Golden Topminnow	77
Largemouth Bass	2
Least Killifish	830
Mayan Cichlid	43
Oscar	5
Sailfin Molly	1872
Spotted Tilapia	6
Walking Catfish	1

Table 4. Number of observations of each species of anuran during sugarcane surveys. These are not numbers of individuals only but may also be an observation of a chorus comprised of more than one individual.

AnuranSpecies	Number of times counted
Frog, Greenhouse	57
Frog, Little Grass	42
Frog, Pig	154
Frog, Southern Chorus	10
Frog, Southern Cricket	143
Frog, Southern Leopard	363
Green Treefrog	1
Toad, Marine	28
Toad, Narrowmouth	101
Toad, Oak	8
Toad, Southern	413
Treefrog, Cuban	11
Treefrog, Green	182
Treefrog, Squirrel	151

Table 5. Numbers of reptiles observed during general agricultural surveys.

Reptile Species Name	Number of observations
Alligator	33
Anole, Brown	467
Anole, Green	10
Cooter, Florida	2
Cooter, Peninsular	9
Cottonmouth, Eastern	12
Gecko sp.	30
Kingsnake, Florida	27
Lizard, Eastern Slender Glass	2
Racer, Black	5
Rattlesnake, Dusky Pygmy	1
Skink, Ground	1
Slider, Red-bellied	2
Snake Eggs	0
Snake Skin	1
Snake, Banded Water	16
Snake, Brown Water	1
Snake, Corn	3
Snake, Eastern Garter	8
Snake, Eastern Ribbon	4
Snake, Everglades Rat	1
Snake, Rough Green	1
Snake, Yellow Rat	13
Turtle, Florida Box	1
Turtle, Florida Softshell	2
Turtle, Common Snapping	3
Watersnake, Banded	11
Watersnake, Brown	4
Watersnake, Florida	18

Table 6. Number of mammals observed during general agricultural surveys.

Mammal Species	Number Observations
Armadillo	3
Bobcat	22
Cottontail, Northern	107
Deer, White-tailed	9
Marsh, Rabbit	4
Muskrat, Round-tailed	7
Opposum, Virginia	4
Otter, River	9
Pig, Feral	6
Rabbit, Marsh	201
Raccoon	21
Rat, Cotton	4
Rat, Rice	3
Squirrel, Gray	2

Table 7. Numbers of birds observed during sugarcane, rice and fallow field surveys.

Bird Species	Total
Anhinga	231
Bittern, American	2
Bittern, Least	59
Blackbird, Red-winged	5216
Bobwhite, Northern	21
Caracara, Crested	10
Cardinal, Northern	89
Catbird, Gray	27
Collared-Dove, Eurasian	21
Coot, American	1
Cormorant, Double-Crested	10
Crane, Sandhill	8
Crow, American	18
Crow, Fish	
Dove, Common-Ground	237
Dove, Mourning	74
Dove, White-winged	23
Dowitcher, Short-billed	4
Duck, Mottled	441
Duck, Ruddy	4
Eagle, Bald	5
Egret, Cattle	1555

Egret, Great	1483
Egret, Snowy	953
Falcon, Peregrine	2
Flycatcher, Great Crested	2
Gallinule, Purple	189
Gnatcatcher, Blue-Grey	1
Grackle, Boat-tailed	2380
Grackle, Common	7
Grebe, Pied-billed	7
Ground-Dove, Common	10
Gull, Laughing	155
Gull, Ring-billed	3
Harrier, Northern	89
Hawk, Red-shouldered	117
Hawk, Red-tailed	44
Hawk, Sharp-shinned	1
Hawk, Short-tailed	1
Heron, Great Blue	154
Heron, Green	233
Heron, Little Blue	346
Heron, Tricolored	676
Ibis, Glossy	1005
Ibis, White	548
Jay, Blue	40
Kestrel, American	200
Killdeer	732
Kingbird, Grey	1
Kingfisher, Belted	21
Kite, Snail	7
Kite, Swallow-tailed	30
Limpkin	31
Meadowlark, Eastern	2
Merlin	1
Mockingbird, Northern	23
Moorhen, Common	2014
Nighthawk, Common	203
Nighthawk, Lesser	3
Night-Heron, Black-crowned	31
Night-Heron, Yellow-crowned	78
Osprey	53
Owl, Barn	112
Owl, Barred	11
Owl, Burrowing	5
Owl. Short-eared	1
Parakeet, Monk	65
Pelican, American White	31
Phoebe, Eastern	5
Pigeon, Rock	6
Plover, Semipalmated	47

Plover, Wilson's	1
Rail, King	69
Robin, American	1
Ruff	1
Sandpiper, Least	26
Sandpiper, Pectoral	6
Sandpiper, Semipalmated	2
Sandpiper, Solitary	12
Sandpiper, Spotted	7
Sandpiper, Stilt	1
Shrike, Loggerhead	10
Skimmer, Black	
Sparrow, Savannah	13
Spoonbill, Roseate	68
Stilt, Black-necked	1368
Stork, Wood	1299
Swallow, Bank	1
Swallow, Barn	827
Swallow, Northern rough-winged	26
Swallow, Tree	400
Teal, Blue-Winged	11
Tern, Black	52
Tern, Common	3
Tern, Gull-billed	15
Tern, Least	31
Tern, Royal	1
Tern, Sandwich	3
Thrasher, Brown	1
Turkey, Wild	3
Vulture, Black	113
Vulture, Turkey	864
Warbler, Palm	221
Warbler, Prairie	1
Warbler, Tennessee	1
Warbler, Yellow-rumped	9
Waterthrush, Northern	1
Whistling-Duck, Black-bellied	82
Whistling-Duck, Fulvous	703
Woodpecker, Pileated	21
Woodpecker, Red-Bellied	11
Woodpecker, Red-headed	1
Wren, Carolina	1
Yellowlegs, Greater	14
Yellowlegs, Lesser	34
Yellowthroat, Common	863

Appendix 1. Photos of study locations, methods and animals used and observed during the EAA wildlife study.

Rice field illustrating field ditch and young growing rice.

Fallow flooded field with a variety of bird species. This was a fairly shallow field with emergent vegetation and was popular with a variety of wading and shore birds.

Sugarcane field with adjacent road and canal. This photo illustrates a brushy edge that is utilized by many wildlife species.

A Roseate Spoonbill in one of the impoundments at LOX. The impoundments are managed for wildlife and support a variety of native wetland plant species.

Wendy Bear, technician, setting a minnow trap at the edge of a rice field and adjacent to a field ditch.

Michelle Casler, technician, observing and counting birds in a young rice field.

A variety of fish that were captured in a Breder trap. This is a closed plexiglass trap that was used to census fish in addition to minnow traps.

A Wood Stork on a dirt road adjacent to a mature rice field. Other birds can be seen foraging for fish in the ditch between two fields.

A Florida Kingsnake observed during a reptile and amphibian survey in sugarcane (herparoos). This was a cool day and the snake is shedding and thus easily approachable.

A Bobcat that was observed hunting in newly harvested sugarcane fields.

The few trees and dead snags associated with canals and agricultural fields are very attractive roosting and perching habitat for a variety of birds.