

**A Species Action Plan for the
Lower Keys Population of the
Striped Mud Turtle
(*Kinosternon baurii*)**

**Final Draft
November 1, 2013**



Florida Fish and Wildlife Conservation Commission
620 South Meridian Street
Tallahassee, FL 32399-1600
Visit us at MyFWC.com

STRIPED MUD TURTLE ACTION PLAN TEAM

Team Leader: William M. Turner, Division of Habitat and Species Conservation
(formerly)

Team Members: Dale R. Jackson, Florida Natural Areas Inventory
Jen M. Williams, Division of Hunting and Game Management

Acknowledgments: Laura Barrett, Division of Habitat and Species Conservation
Brian Beneke, Fish and Wildlife Research Institute
Claire Sunquist Blunden, Office of Policy and Accountability
Randy Grau, Division of Habitat and Species Conservation
Lindsay Nester, Division of Habitat and Species Conservation
Brie Ochoa, Division of Habitat and Species Conservation

Cover photograph of striped mud turtle from Sugarloaf Key, Monroe County, Florida by Richard D. Bartlett.

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EXECUTIVE SUMMARY

The striped mud turtle (*Kinosternon baurii*) is a small, freshwater turtle inhabiting shallow wetlands of the southeastern U.S., including much of Florida. Because of potential isolation and former recognition as a distinct subspecies, striped mud turtles in Florida's Lower Keys have been the subject of conservation concern. The Lower Keys population is known only from mostly small populations (dozens to a few hundred individuals) on 11 islands west of the Seven Mile Bridge.

Principal threats to this turtle are continued loss and degradation of fresh and brackish wetlands through drying, saltwater intrusion, and incompatible management for other rare species (e.g., filling mosquito ditches for protection of Key deer [*Odocoileus virginianus clavium*]); climate change, which may lead to sea level rise, increased frequency and intensity of hurricanes, and exacerbation of drought regimes; predation of nests and turtles; and random events of severe pollution, such as may occur from oil and shipping spills. The Florida Fish and Wildlife Conservation Commission previously listed the Lower Keys population of the striped mud turtle as Threatened; under that protection take was prohibited from the wild. A 2011 biological assessment determined that the Lower Keys population of striped mud turtle met recently adopted criteria – however, staff recommended removing the Lower Keys population of this turtle from the Florida Endangered and Threatened Species List because it is not taxonomically distinct from striped mud turtles elsewhere.

There are 2 objectives of this plan: to maintain the current extent of occurrence and to maintain or increase population sizes of striped mud turtles in the Lower Keys. Strategies for achieving these objectives include maintaining or improving historical water quality, water quantity, and habitat characteristics of fresh to brackish wetlands and nearby nesting habitats and identifying and conserving private lands that provide that habitat for the species. Additional strategies include maintaining current regulatory protections, educating the public and law enforcement personnel about the species and rules governing its conservation, encouraging land managers to consider the species' welfare and requirements in all management activities (potentially including predator control) on their lands, and supporting research that facilitates conservation of the species.

This plan details the actions necessary to improve the conservation status of the Lower Keys population of the striped mud turtle. A summary of this plan will be included in the Imperiled Species Management Plan (ISMP), in satisfaction of the management plan requirements in Chapter 68A-27, Florida Administrative Code, Rules Relating to Endangered or Threatened Species. The ISMP will address comprehensive management needs for 60 of Florida's imperiled species and will include an implementation plan; rule recommendations; permitting standards and exempt activities; anticipated economic, ecological, and social impacts; projected costs of implementation and identification of funding sources; and a revision schedule. The imperiled species management planning process relies heavily on stakeholder input and partner support. This level of involvement and support is also critical to the successful implementation of the ISMP. Any significant changes to this plan will be made with the continued involvement of stakeholders.

TABLE OF CONTENTS

STRIPED MUD TURTLE ACTION PLAN TEAM..... ii
 EXECUTIVE SUMMARY iii
 LIST OF TABLES v
 LIST OF FIGURES vi
 GLOSSARY OF TERMS AND ACRONYMS..... vii
 INTRODUCTION 1
 Biological Background..... 1
 Conservation History..... 3
 Threats and Recommended Listing Status 4
 CONSERVATION GOAL AND OBJECTIVES 7
 CONSERVATION ACTIONS 8
 Habitat Conservation and Management 8
 Population Management..... 12
 Monitoring and Research 13
 Rule and Permitting Intent 16
 Law Enforcement 17
 Incentives and Influencing 17
 Education and Outreach 17
 Coordination with Other Entities 18
 LITERATURE CITED 22

LIST OF TABLES

Table 1. Conservation lands (managed areas) within the range of striped mud turtles in the Lower Keys, Monroe County, Florida, and known or likely to harbor appropriate habitat..... 10
Table 2. Conservation Action Table. 20

LIST OF FIGURES

Figure 1. Striped mud turtle from Sugarloaf Key, Monroe County, Florida..... 1
Figure 2. Head of striped mud turtle..... 1
Figure 3. Ventral view of striped mud turtle from Sugarloaf Key, Monroe County, Florida..... 2
Figure 4. Documented occurrences and distribution of the striped mud turtle in the Lower Keys,
Monroe County, Florida..... 3

GLOSSARY OF TERMS AND ACRONYMS

Aestivation: A period of inactivity when functions such as foraging and reproduction halt; mud turtles, which live and forage in wetlands, commonly aestivate below the ground surface during conditions in which the aquatic environment is unsuitable (e.g., seasonal drought).

ARC: Acquisition and Restoration Council

Area of Occupancy: The area within a species' extent of occurrence (see Extent of Occurrence) that is occupied by the taxon, excluding cases of vagrancy. This reflects the fact that a taxon will not usually occur throughout the area of its extent of occurrence, which may contain unsuitable or unoccupied habitats (as defined by International Union for Conservation of Nature [IUCN]).

BRG: Biological review group, a group of taxa experts convened to assess the biological status of taxa using criteria specified in Chapter 68A-27, Florida Administrative Code, and following the protocols in the Guidelines for Application of the IUCN Red List Criteria at Regional Levels (Version 3.0) and Guidelines for Using the IUCN Red List Categories and Criteria (Version 8.1).

BSR: Biological status review report, the summary of the biological review group's findings. Includes a Florida Fish and Wildlife Conservation Commission (FWC) staff recommendation on whether or not the species status meets the listing criteria in Rule 68A-27.001, Florida Administrative Code. These criteria, based on IUCN criteria and IUCN guidelines, are used to help decide if a species should be added to or removed from the Florida Endangered and Threatened Species List. In addition, FWC staff may provide within the report a biologically justified opinion that differs from the criteria-based finding.

Carapace: Lower portion of a turtle's shell

DEP: Florida Department of Environmental Protection

Extent of Occurrence: The geographic area encompassing all observations of individuals of a species, including intervening areas of unoccupied habitat. Synonymous with range. See also Area of Occupancy (as defined by IUCN).

F.A.C.: Florida Administrative Code. The Department of State's Administrative Code, Register and Laws Section is the filing point for rules promulgated by state regulatory agencies. Agency rulemaking is governed by Chapter 120, Florida Statutes, the Administrative Procedures Act. Rules are published in the Florida Administrative Code.

FKE: Florida Keys Ecosystem

GLOSSARY OF TERMS AND ACRONYMS

FNAI: Florida Natural Areas Inventory, a non-profit organization administered by Florida State University and dedicated to gathering, interpreting, and disseminating information critical to the conservation of Florida's biological diversity.

Forage: To search for, acquire, and ingest food

Fragmentation: A process of environmental change, commonly caused by human-related land conversion, where once-connected habitats become divided into separate fragments.

FWC: The Florida Fish and Wildlife Conservation Commission, the state agency constitutionally mandated to protect and manage Florida's native fish and wildlife species.

GIS: Geographic Information System

Habitat: The area used for any part of the life cycle of a species (including foraging, breeding, and sheltering).

ISMP: Imperiled Species Management Plan

IUCN: International Union for the Conservation of Nature, a professional global conservation network

IUCN Red List (IUCN Red List of Threatened Species): An objective, global approach for evaluating the conservation status of plant and animal species, the goals of which are to: Identify and document those species most in need of conservation attention if global extinction rates are to be reduced; and provide a global index of the state of change of biodiversity.

OFW: Outstanding Florida Water; see Rule 62-302.700 F.A.C.

Pine rockland: A natural community unique to extreme southern Florida characterized by an open canopy of South Florida slash pine (*Pinus elliottii* var. *densa*) with a diverse understory and herbaceous layer. Rare and endemic plant and animal species are abundant in pine rocklands. The substrate consists of exposed oolitic limestone with numerous depressions and solution holes where nutrient-poor soil and organic debris accumulate. Pine rockland is a fire-dependent natural community, and similar habitat occurs in the Bahamas where Caribbean pine (*Pinus caribaea*) is the dominant pine.

Plastron: Lower portion of a turtle's shell.

Predation (depredation, predated): To be killed or destroyed by a predator.

Scientific Collection Permit: A permit issued for activities that include salvage, voucher, bird banding, wildlife possession, or special purpose. Applications must demonstrate a scientific or educational benefit for the species, and must identify the purpose, scope, objective, methodology, location, and duration of the project.

GLOSSARY OF TERMS AND ACRONYMS

SFWMD: South Florida Water Management District

Subspecies: A geographic race of a species that typically is distinguishable from related races by physical characteristics such as color pattern or size.

Take: As defined in Chapter 68A-1.004, F.A.C. (General Prohibitions) "Taking, attempting to take, pursuing, hunting, molesting, capturing, or killing any wildlife or freshwater fish, or their nests or eggs by any means whether or not such actions result in obtaining possession of such wildlife or freshwater fish or their nests or eggs."

TNC: The Nature Conservancy.

USFWS: United States Fish and Wildlife Service, the federal agency mandated to protect and manage the nation's native freshwater fish and wildlife resources.

INTRODUCTION

Biological Background

Striped mud turtles from the Lower Keys were formerly considered a distinct subspecies (Stejneger 1925, Uzzell and Schwartz 1955). However, more recent morphological and molecular studies (Iverson 1978, Lamb and Lovich 1990, Karl and Wilson 2001) have indicated that Lower Keys specimens are not sufficiently distinct to justify taxonomic recognition, and most experts do not recognize the Lower Keys population of the striped mud turtle as taxonomically distinct.

The striped mud turtle (*Kinosternon baurii*) is a small (shell length to 118 mm [4.5 in]), freshwater turtle inhabiting shallow wetlands of the southeastern U.S., including much of Florida. The species normally has 3 light longitudinal stripes on its carapace, which runs from tan to black in color (for photographs, see Wilson et al. 2006 and Krysko et al. 2011a);



Figure 2. Head of striped mud turtle. Photograph by Richard D. Bartlett.



Figure 1. Striped mud turtle from Sugarloaf Key, Monroe County, Florida. Photograph by Richard D. Bartlett.

however, the stripes are inconspicuous in turtles from Florida's Lower Keys and some other parts of the species' range (Figure 1). Though lacking shell stripes, these turtles normally still retain a pair of yellow to cream facial stripes on each side of the head (Figure 2), a characteristic not unlike that of the related stinkpot (*Sternotherus odoratus*), which is not native to the Lower Keys. The plastron (Figure 3) is brown to dark yellow and bears 2 transverse hinges that allow movement of the anterior and posterior lobes, thereby effectively closing the shell.

In the Lower Keys, striped mud turtles (also referred to as Lower Keys mud turtles) inhabit small, ephemeral, freshwater ponds and brackish water ponds with salinities below 15 ppt (parts per thousand); some manmade mosquito-control ditches with longer hydroperiods also support high numbers (Dunson 1981, Dunson 1992). Turtles use surrounding uplands to nest, migrate between ponds, and escape drying brackish ponds as they become too saline (Dunson 1992). Though not studied in the Keys, the species' varied diet elsewhere includes insects, worms, snails, algae, seeds, and the scavenged remains of vertebrates (e.g., small fishes and amphibians). Few data on the life history of freshwater turtles in the Florida Keys exist. Elsewhere, females annually lay between 2 and 4 clutches of 1 to 6 eggs each, with nesting peaks in the fall and early summer, though nesting likely occurs in most months (Iverson 1977, Wilson et al. 1999, Meshaka and Blind 2001, Wilson et al. 2006). For more information about the species, both statewide and rangewide, see Wilson et al. (2006) and Ernst and Lovich (2009).



Figure 3. Ventral view of striped mud turtle from Sugarloaf Key, Monroe County, Florida. Photograph by Richard D. Bartlett.

Striped mud turtles principally inhabit the coastal plain of the southeastern U.S. from Virginia to Florida, including the entire peninsula. At present, the Lower Keys population is known only from 11 islands in the Lower Keys, west of the Seven Mile Bridge ([Figure 4](#); see also Wilson et al. 2006 and Krysko et al. 2011a).

Conservation History

Because of the extremely localized distribution and rarity of the Lower Keys population of striped mud turtles, coupled with threats to its habitat and perceived population declines, the Florida Fish and Wildlife Conservation Commission (FWC) designated the population as a Threatened species in 1975 and subsequently elevated its status to Endangered in 1979; it has since been returned to the Threatened category. These actions prohibited take of the Lower Keys population of striped mud turtle without a permit. In 2009, the FWC prohibited selling wild turtles, taking more than one turtle per day from the wild, and transporting more than one turtle (Rule 68A-25.002, Florida Administrative Code [F.A.C.]).

Although not specifically directed towards the striped mud turtle, efforts to conserve land in this unique habitat have benefitted the species. As a result, some sites supporting or having the potential to support mud turtles are included within a mosaic of lands conserved by both public (federal, state, and local) and private entities (see [Habitat Conservation and Management](#)). Among these is the National Key Deer Refuge, managed by the U.S. Fish and Wildlife Service (USFWS). Most state-conserved lands were acquired through Florida Forever and predecessor

programs. The Coupon Bight Key Deer project on Big Pine Key and No Name Key was approved in 1985. As of February 2012, the project had acquired 690 ha (1,706 ac) of the desired total 1,354 ha (3,347 ac). Another important conservation site is the Florida Keys Ecosystem project (FKE), created in 1995 by combining two existing projects, the Hammocks of the Lower Keys and Tropical Flyways. In 2004, the FWC and USFWS co-sponsored a major expansion of the project in the Lower Keys, resulting in successful conservation of the habitat. Additional amendments since 2005 by multiple sponsors brought the entire acreage of FKE to 5,290 ha (13,070 ac). As of February 2012, 1,821 ha (4,500 ac) of the FKE have been placed in public ownership, leaving 3,468 ha (8,571 ac) remaining to be acquired. FWC manages the majority of the FKE lands as the Florida Keys Wildlife and Environmental Area.

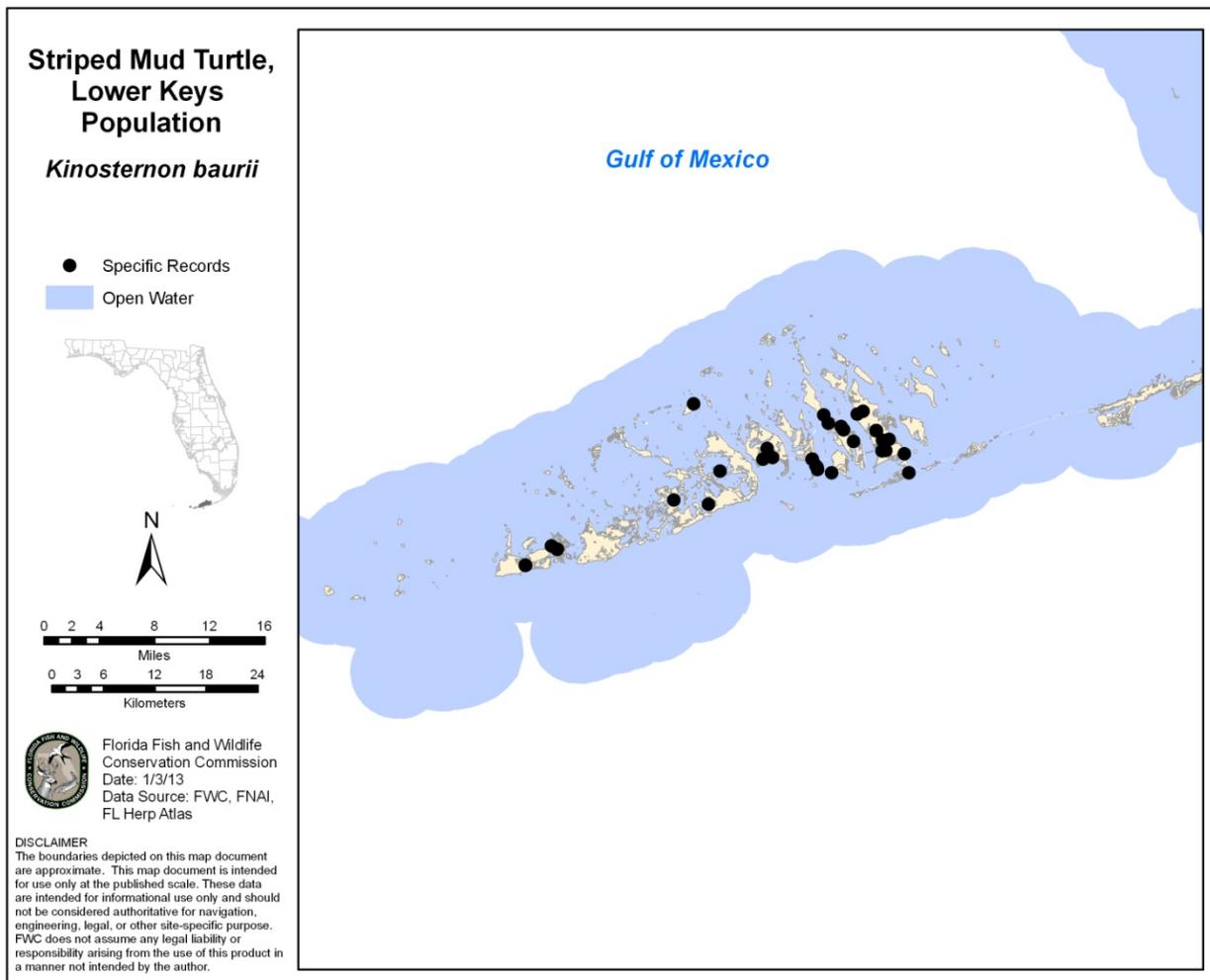


Figure 4. Documented occurrences and distribution of the striped mud turtle in the Lower Keys, Monroe County, Florida. Specific localities are from Krysko et al. (2011) as supplemented by data in the Florida Natural Areas Inventory element occurrence database.

Threats and Recommended Listing Status

Habitat Loss and Degradation

The principal threat to Lower Keys mud turtles is continued loss or degradation of the small, often isolated, and ephemeral bodies of fresh to moderately-brackish water upon which they depend. Naturally rare in the Keys, such waterbodies are threatened principally by human use of the shallow water table, leading to drying or saltwater intrusion, as well as drainage alteration for mosquito control and mosquito-ditch filling for management of Key deer. Additional threats include predation of nests and turtles and random events of severe pollution, such as those that could occur from oil and shipping spills.

Sea Level Rise and Hurricanes

In the Lower Keys, striped mud turtles and their prey require fresh water, making them vulnerable to storm surges that increase salinity of freshwater wetlands. Hurricanes and associated seawater surges could probably kill some striped mud turtles and their prey. For example, after Hurricane Georges, a Category 2 hurricane, 4 of 15 monitored freshwater holes in the Lower Keys had salinities >15 ppt due to the storm surge, a salinity higher than usually tolerated by striped mud turtles. The altered salinity remained months later in some places (Lopez et al. 2004). A stronger storm would have a greater impact due to stronger winds and greater storm surge (>3.5 m). A storm surge of 4 m (13 ft) would result in the complete submersion of Big Pine Key and No Name Key, which together provide about 51% of the 276 freshwater sources for the Key Deer (*Odocoileus virginianus clavium*) and presumably the striped mud turtles (Lopez et al. 2004). In 2005, Hurricane Wilma (Category 3) passed just north of the Florida Keys, causing 2 storm surges. The second storm surge caused maximum storm tides 1.5 to 1.8 m (5 to 6 ft) above mean sea level in Key West, flooding approximately 60% of the city. Hurricane Wilma caused a storm surge of 1.5 to 2.4 m (5 to 8 ft) on Boca Chica and Big Pine keys (Kasper 2007). Although the species has survived many hurricanes, severe saltwater overwash from very large storms has the potential to increase salt content of freshwater ponds and brackish water ponds to an extent that would eliminate them as suitable habitat. Sea level rise will increase maximum high tides and will likely exacerbate the effects of storm surges (Florida Oceans and Coastal Council 2009), which will likely impact this species.

Climate change and associated sea level rise present exceptional challenges to vulnerable species in the Florida Keys. Globally, sea level is rising at an increasing rate (Florida Oceans and Coastal Council 2009). Sea level rose in Key West approximately 22.25 cm (8.76 in) between 1913 and 2006, a rate of about 2.24 mm per year. This rate appears to be increasing, according to trend analyses by the National Oceanic and Atmospheric Administration (2013). While sea level rise is a gradual change, it compounds the effects of many other weather events, including spring tides and storm surges, causing habitat damage, migration, elimination, and conversion into other habitat types. Sea level rise has been modeled extensively for the Florida Keys, especially for the National Wildlife Refuges. Sea Level Affecting Marshes Model (SLAMM) shows that there will likely be significant habitat loss in the Florida Keys that will affect many Keys species; more information [here](#). For example, SLAMM modeling for the Great White Heron National Wildlife Refuge (NWR) in the lower and middle Keys is predicted to lose 77% of mangrove habitat, 98% of beach, 94% of irregularly flooded marsh, and 69% of regularly flooded marsh (Warren Pinnacle Consulting 2011a). Similarly, SLAMM predicts that Crocodile Lake NWR in the upper

Keys will be moderately impacted. Up to 98% of refuge mangrove, which comprises the vast majority of the refuge, is predicted to be lost. Simulations using SLAMM predict Key West NWR will be severely impacted under every sea level rise scenario tested. Under the scenario where sea level rises 1.5 m by 2100, the entire refuge would be under water and unsuitable for striped mud turtles (Warren Pinnacle Consulting 2011b).

Invasive Species

The red imported fire ant (*Solenopsis invicta*) has invaded southern Florida and the Keys. Fire ants have the potential to prey upon turtle eggs and neonates that have yet to reach the water (e.g., Ewert and Jackson 1994, Jackson and Walker 1997). In a study conducted in the Lower Keys, transects with the highest probability of the presence of fire ants were those closest to roads and with the largest amount of development within a 150-m (492-ft) radius (Forys et al. 2002).

The increasing numbers of introduced lizard species in the Miami area and on some of the Keys (Meshaka et al. 2004, Krysko et al. 2011b) could have an impact if they locate and prey on hatchling striped mud turtles or mud turtle eggs. Feral and free-roaming domestic animals may also be a threat to this species. Opossums (*Didelphis virginiana*) from the Upper Keys have recently been introduced to the Lower Keys, which were previously uninhabited by the species (Randy Grau, FWC, personal communication). Where these potential predators are in higher numbers due to human supplementation (intentional and unintentional), unnatural levels of predation may be a significant threat, especially in synergy with other threats

Recommended Listing Status

In 2010, FWC directed staff to evaluate the status of all state-listed species (including subspecies and populations) that had not undergone a status review in the past decade. To address this charge, staff conducted a literature review and solicited information from the public on the status of the Lower Keys mud turtle. A Biological Review Group (BRG) of experts was subsequently convened to assess the biological status of the species using [listing criteria](#) specified in Rule 68A-27.001, F.A.C., and following the protocols in the Guidelines for Application of the International Union for Conservation of Nature (IUCN) Red List Criteria at Regional Levels (Version 3.0) and Guidelines for Using the IUCN Red List Categories and Criteria (Version 8.1). Staff from FWC developed an initial draft of a Biological Status Review Report (BSR), which included the BRG's findings and a preliminary listing recommendation from staff. The draft was sent out for peer review, and the reviewers' input was incorporated into a final [Biological Status Review Report](#) (FWC 2011a).

The BRG found that the striped mud turtle (Lower Keys population) met the following criteria for listing:

- Criterion A, Population Size Reduction. The BRG inferred population size reduction of at least 30% over the last 3 generations and suspected population size reduction of at least 30% over any 3-generation period, where the time period includes both the past and the future.
- Criterion B, Geographic Range. The BRG estimated that the current extent of occurrence of the striped mud turtle in the Lower Keys is less than 20,000 km² (7,722 mi²), with area of occupancy less than 2,000 km² (772 mi²); that overall the population is severely

fragmented; and that a continuing decline in extent of occurrence, area of occupancy, extent and quality of habitat, number of locations or subpopulations, and number of mature individuals, can be expected.

- Criterion C, Population Size and Trend. The BRG estimated population size of the striped mud turtle in the Lower Keys at fewer than 10,000 mature individuals, with a suspected continuing decline of at least 10% in 3 generations, a projected continuing decline in numbers of mature individuals, and no subpopulation estimated to contain more than 1,000 mature individuals.
- Criterion D, Population Very Small or Restricted. The BRG confirmed that the population of striped mud turtles in the Lower Keys has a very restricted area of occupancy (typically less than 20 km² [8 mi²]) such that it is prone to the effects of human activities or stochastic events within a short time period in an uncertain future.

The BRG concluded from the biological assessment that the Lower Keys population of the striped mud turtle met the listing criteria. However, because FWC staff concluded that the Lower Keys population of the striped mud turtle does not meet the definition of isolated population (significant and discrete population of a species), they recommended that the Lower Keys population of the striped mud turtle not be listed as a Threatened species and that it be removed from the Species of Special Concern List.

CONSERVATION GOAL AND OBJECTIVES

Goal

Conservation status of the striped mud turtle (Lower Keys population) is improved to the point that the species is secure within its historical range.

Objectives

I. Maintain the current extent of occurrence (range) of the striped mud turtle in the Lower Keys.

Rationale

Maintaining striped mud turtle habitat is essential to preventing reductions to the species' extent of occurrence. Striped mud turtles in the Lower Keys depend on waters of salinity less than 15 ppt. In the Lower Keys, natural freshwater habitats tend to be small and subject to a multitude of external threats. These waterbodies are essential for the continuance of the Lower Keys population of striped mud turtles. Where habitat is lost, new habitat could be created (mitigation) in the form of manmade freshwater habitat. In conjunction with this objective, further scientific studies to determine the degree of isolation (in terms of exchange and movements of individuals as well as genetics) of Lower Keys mud turtles from those in the upper Keys and southern peninsula are vital to assessing this population's extent of occurrence and conservation status.

II. Maintain or increase the current population of striped mud turtles in the Lower Keys.

Rationale

Local colonies (subpopulations) are notably small, with numbers of individuals ranging from a few dozen to a few hundred. Loss of even a few individuals from such small populations could have dire consequences.

CONSERVATION ACTIONS

The following sections describe the conservation actions that will make the greatest contribution toward achieving the conservation objectives. Actions are grouped by category (e.g., Habitat Conservation and Management, Population Management). The Conservation Action Table ([Table 2](#)) provides information on action priority, urgency, potential funding sources, likely effectiveness, identified partners, and leads for implementation.

Maintaining or improving the conservation status of striped mud turtles in the Lower Keys requires a 2-tiered approach. First, it is critical to conserve the species' habitat from direct loss or degradation (structurally, chemically, or biotically). Second, actions need to be taken or continued to prevent excessive loss (e.g., from predation, disease, human activity, and incidental factors) of individuals of all life stages from existing populations. Education and enforcement are vital to achieving success across both tiers. This section elaborates upon actions that will address and supplement this approach to facilitate achievement of the conservation goal.

Habitat Conservation and Management

Habitat Conservation

Habitat loss is the principal threat to Lower Keys populations of the striped mud turtle. Successful conservation of this species in the Lower Keys relies upon the ability of public and private lands to maintain freshwater to moderately brackish (salinity < 15 ppt; Dunson 1979, 1981) wetlands in association with surrounding terrestrial (upland) habitats, both of which are essential to supporting mud turtles in the Lower Keys. Wetlands retaining water at least several months of the year are necessary for turtles to forage. Terrestrial habitat is needed for nesting and aestivation (Dunson 1992). Additionally, maintenance of multiple wetlands within a habitat mosaic that permits overland, inter-wetland movements may be important to maintaining metapopulations of the species. Although movement patterns have not been documented thoroughly in the Florida Keys, individuals elsewhere (South Carolina) have been shown to make overland excursions exceeding 3 km (1.9 mi; Tuberville et al. 1996), a distance greater than the width of most islands in the Lower Keys.

Action 1 Identify current conservation lands and privately-owned potential conservation lands that support Lower Keys mud turtles or their habitats and which merit protection and conservation attention for this species.

It is critical to identify all land management units in the Lower Keys known to support mud turtles so that they can be appropriately managed to address species needs. It is also critical to identify private lands suitable for conservation via fee simple or less-than-fee simple measures (e.g., conservation easements) that contain or lie within 500 m (1,640 ft) of surficial fresh to slightly brackish waters and would complement currently conserved lands in the Lower Keys. Efforts should be made to acquire or secure perpetual conservation of these private lands. This will entail identification of landowners willing to sell or lease their lands or property rights to assure conservation of wildlife. Lower Keys freshwater wetlands have been [mapped](#) by Monroe County.

Wetland habitat in the Lower Keys is predominantly conserved through a 2-fold approach. Wetlands on federal lands lie principally within the National Key Deer Refuge, managed by the USFWS. Wetlands on private lands are under the jurisdiction of Monroe County, which offers them stringent protective measures under the Monroe County Comprehensive Plan.

Chapter 163.3177, Florida Statutes, requires that county comprehensive growth management plans include a conservation element. The conservation element must include the identification of areas within the county that are locations of important wildlife or habitat resources, including State-listed species. This element must contain principles, guidelines, and standards for conservation that restrict activities known to adversely affect the survival of these species. The FWC is identified as a state agency authorized to review county growth management plans, including any amendments to ensure important state fish, wildlife, and habitat resources are adequately considered. In addition, local government land development regulations require conditions for land and water uses that specify how such uses will be administered to be consistent with the conservation element of the county growth management plans. Therefore, interagency collaboration on the review of the conservation element of these plans is essential for ensuring that they consider wildlife habitat within the county.

The most durable means for conserving mud turtle habitat is simply purchasing freshwater wetlands and adjacent uplands (though not sufficient without conservation of the underlying freshwater source as well); less-than-fee-simple conservation may suffice if appropriate and perpetual measures can be ensured. This has been accomplished with some success across the mud turtle's range and has involved programs at the federal, state, local, and private (non-governmental organization) levels. However, numerous remaining opportunities exist and need to be pursued, which will entail the input of substantial additional funding.

A geographic information system (GIS) review of the Conservation Lands (Managed Areas) Database of the Florida Natural Areas Inventory (FNAI) was conducted to evaluate the extent of conserved lands inhabited by mud turtles in the Lower Keys. The review also noted managing agencies and organizations for all such tracts so that they could be considered as potential partners in the implementation of this plan. Similarly, the FNAI Site Database was examined to pinpoint formal land conservation projects under consideration through various programs, chiefly the Florida Forever program. This program is funded through annual appropriation by the Florida Legislature; in recent years funding has been insufficient to accomplish program goals.

The GIS review revealed that most known mud turtle occurrences were either within or near managed areas ([Table 1](#)). The managers of all of these tracts are potential partners for implementing the actions outlined in this plan. These include 2 federal agencies, 1 state agency, 2 local government agencies, and 1 private organization. Additional habitat meriting protection occurs within the Coupon Bight Key Deer and FKE Florida Forever land acquisition projects; it is acreage that has not yet been acquired. In addition, several other entities should be considered for potential partnership. Striped mud turtles reportedly occur in fair numbers on Stock Island on the grounds of the Key West Botanical Garden, the Lower Keys Medical Center (formerly Monroe General Hospital), and the Key West Country Club. The FWC should communicate with each potential partner about its role in conserving mud turtles and their habitat and provide copies of this plan to all appropriate offices and personnel.

Achieving this action will facilitate maintaining striped mud turtles in the Lower Keys by: 1) allowing wildlife managers to assess whether existing conservation lands suitably managed are sufficient to maintain the population’s current extent of occurrence (range), 2) identifying lands of highest priority for protection should this not be the case, and 3) identifying management agencies that are potential cooperators in instituting the recommendations in this plan.

Table 1. Conservation lands (managed areas) within the range of striped mud turtles in the Lower Keys, Monroe County, Florida, and known or likely to harbor appropriate habitat. Keys are arranged from east to west. Information is based on March 2012 data from the Florida Natural Areas Inventory.

Managed Area	Ownership	Managing Agency	Key
National Key Deer Refuge	Federal	USFWS	Big Pine, Cudjoe (also No Name and Knockemdown)
Florida Keys Wildlife and Environmental Area	State	FWC	Little Torch, Middle Torch, Big Torch, Ramrod, Cudjoe, Sugarloaf
John J. Pescatello Torchwood Hammock Preserve	Private	TNC	Little Torch, southern end
Monroe County-Managed Areas	State	Monroe County	Little Torch, Ramrod, Summerland, Middle Torch, Big Torch, Ramrod, Cudjoe, Sugarloaf, Big Pine
Naval Air Station Key West	Federal	U. S. Navy	(Boca Chica: species not yet confirmed here)
Little Hamaca Park	Local Government	City of Key West	Key West

Habitat Management

Action 2 Maintain or enhance water quality and quantity in all freshwater and slightly brackish wetlands in the Lower Keys.

Habitat management for Lower Keys mud turtles should focus on maintaining physiographic, structural and chemical characteristics of freshwater to moderately brackish wetlands throughout the Lower Keys. Pollution, sedimentation, and disturbance should be minimized. Drainage of such ponds for mosquito control is not in the best interest of mud turtles, although the ditches, which can maintain deeper water than some natural ponds for longer periods, do offer alternative habitat that can support fairly dense populations of turtles (Dunson 1992, Wilson et al. 2006). In situations where monitoring reveals moderate to large populations, it is inadvisable to backfill ditches (which is sometimes done for Key deer management) without first ensuring that associated ponds will maintain an adequate hydroperiod to support displaced turtles.

As for all aquatic species, conservation of striped mud turtles in the Lower Keys depends upon maintenance of moderate- to high-quality waters. The lower limits of water quality tolerated by these turtles have not been determined, but the species (and some of its prey) logically would be excluded by substantial pollution.

Several federal and state agencies in Florida work together to maintain quality aquatic habitats. The U.S. Environmental Protection Agency, Florida Department of Environmental Protection (DEP), and the 5 water management districts monitor and regulate water quality and quantity (e.g., minimum flows and levels) to maintain healthy conditions for aquatic plants, fish, and other wildlife. The FWC Invasive Plant Management and Aquatic Habitat Enhancement and Restoration sections work to monitor, restore, and control aquatic plants. They accomplish this through permit reviews, control of invasive species, and habitat enhancement projects for wildlife. These habitat management efforts, coupled with those of Monroe County and various agencies that manage public lands in the Keys ([Table 1](#)), should facilitate maintenance of the striped mud turtle's principal aquatic habitats in the Lower Keys.

One additional state program, Outstanding Florida Waters (OFW), bears specific mention. The OFW is a special category of waterbodies within the state that are considered worthy of special protection because of their natural attributes. Such designation empowers the DEP and the appropriate water management district(s) to assure that activities and proposed projects will not lower existing ambient water quality of the OFW. Although a principal action outlined in this plan is to secure remaining private lands that encompass wetlands inhabited by Lower Keys mud turtles, complete fulfillment will be difficult for economic reasons. System-wide benefits can still be achieved, however, by ensuring that all Lower Keys wetlands maintain a designation of OFW. Waters of the Florida Keys are designated as OFW. This designation applies to all jurisdictional wetlands within the Keys except for those areas specifically excluded, such as the mixing zone associated with the Stock Island power plant, Key West sewage outfall, and artificial/constructed wetlands (E. Shaw, DEP, personal communication). It is important to ensure that all wetlands inhabited by mud turtles are included within the Florida Keys OFW.

Unfortunately, efforts to conserve freshwater wetland habitats in the Lower Keys may be insignificant if climatic or anthropogenic variables alter the landscape. Saltwater intrusion, which may increase with sea level rise (Ross et al. 2009) or greater water withdrawal by the human population, threatens the freshwater source beneath the Keys. Most remaining freshwater wetlands have the potential to become mangrove swamp within the next 100 years (Ross et al. 2009).

Achieving this action will facilitate maintaining the full extent of occurrence of striped mud turtles in the Lower Keys by preserving the species' essential aquatic habitat.

Action 3 Identify and maintain Lower Keys mud turtle nesting and aestivation sites associated with wetlands occupied by the species.

For nesting, it is imperative to conserve natural upland habitat to at least 250 m (820 ft) from wetland edges. Because eggs are normally laid in shallow nests, herbaceous or grassy groundcover is important to conserving developing embryos, which may remain in the nest for a year (based on studies elsewhere in Florida; Wilson et al. 2006). However, very dense

overgrowth of any nesting site with shrubby or hardwood canopy cover potentially can make sites less attractive to nesting females. Based on the mechanism of temperature-dependent sex determination that operates in this species (Ewert et al. 1990), more open (generally warmer) nest sites are more likely to produce female offspring than are more shaded sites. It is appropriate for any management program for this species to include monitoring of known nest sites for potentially deleterious levels of hardwood encroachment that may require some thinning. In situations where such sites may have included open pine rockland habitats, the use of prescribed fire may be necessary to prevent or reduce hardwood encroachment that could lead to loss of solar exposure (on the ground), although timing of fires may require the need to consider aestivating turtles. Until research examines nesting success and offspring sex ratios under varying vegetative conditions in the Lower Keys, maintenance of a somewhat patchy landscape around wetlands may be a suitable management tool for the species. Achieving this action will facilitate maintaining the full extent of occurrence of striped mud turtles in the Lower Keys by preserving the species' essential terrestrial habitat.

Population Management

Action 4 Where high levels of predation (on nests or turtles) are documented, especially on managed conservation lands, institute and maintain appropriate measures to reduce predation. These measures may include various means of predator control, but also various forms of habitat management.

Predation is a natural limiting factor for all turtle populations, with nest predation eclipsing all other sources in terms of number of mortalities. Among chief nest predators is the raccoon (*Procyon lotor*), a species whose population is generally considered to be subsidized by the availability of human garbage as a supplemental food source (Ewert et al. 2006, Jackson 2006). Although not adequately documented, both of these species potentially could have a profound negative effect on nesting success of striped mud turtles. A variety of management actions can be employed to reduce predation of nests and nesting females. Raccoon-removal programs have proven successful elsewhere (Christiansen and Gallaway 1984) but need to be repeated regularly to remain effective and are cost-prohibitive and time- and labor-intensive. Habitat management regimes that mimic natural ecosystem functions, including the regular use of prescribed fire in appropriate seasons, can limit hardwood encroachment in pyrogenic communities, where at least a segment of Lower Keys mud turtle populations may nest. This practice allows for nests to be dispersed across a larger, less predictable landscape that is more difficult for predators to search. If any public visitation sites (e.g., picnic grounds) exist near striped mud turtle habitat, all associated garbage containers should be predator-resistant models in order to reduce an additional food source that can enhance populations of potential nest predators. Achieving this action will facilitate maintaining the Lower Keys population of striped mud turtles by reducing predation and thereby facilitating recruitment, which should help to maintain or increase the species' current population.

Invasive Species

Action 5 Identify the occurrence of any non-native species within the historic range that may affect the habitat, including forage, of Lower Keys mud turtles. Determine effects of these non-native species on mud turtles.

There is insufficient evidence to document that any invasive animal species has a substantial deleterious effect on Lower Keys mud turtles. However, fire ants have the potential to prey upon turtle eggs and neonates that have yet to reach the water (e.g., Ewert and Jackson 1994, Jackson and Walker 1997). If fire ants occur within 250 m (820 ft) of wetlands with striped mud turtles, they should be controlled appropriately. Achieving this will facilitate maintaining the Lower Keys population of striped mud turtles by reducing predation and thereby facilitating recruitment, which should help to maintain or increase the species' current population.

Monitoring and Research*Distributional Surveys and Movement Patterns*

Action 6 Survey and monitor Lower Keys mud turtle microdistribution, including wetlands and ditches where the species is not yet documented but where its occurrence might be anticipated based on known range and presence of suitable habitat.

Despite state listing and calls for more research and surveys for nearly 3 decades (Weaver 1978, Dunson 1992, Wilson et al. 2006), knowledge about the precise distribution and ecology of Lower Keys mud turtles remains inadequate. During research for this plan, biologists from neither the FWC (R. Grau, personal communication) nor USFWS (C. Anderson, National Key Deer Refuge, personal communication) were aware of any recent surveys or reports related to the population. High priority should be given to basic survey work to identify all sites supporting the species and to obtain insight into local population sizes and microhabitat use. Because the species can be captured or intercepted by a variety of inexpensive techniques (e.g., baited hoop traps, drift fences with funnel traps or buckets, and dip netting), basic survey work is very feasible. Detailed records of occurrence of the species should be provided to FNAI in addition to the FWC. Given the predictions for further decline in freshwater habitats in the Lower Keys due to sea level rise (Ross et al. 2009), all populations should be monitored regularly to detect any changes in population size or demographic characteristics (e.g., reproductive failure leading to populations eventually being dominated by old adults).

In conjunction with distributional surveys, studies are needed to determine movement patterns of Lower Keys mud turtles. If any sites of frequent crossings over roads are identified, these should be addressed, as loss of even a few adult females can have negative consequences for the relatively small populations that characterize this species in the Lower Keys. Installing barrier fencing and wildlife tunnels in such situations could be an effective means of addressing such potential problems. This may require cooperation by the Florida Department of Transportation, Monroe County, and the USFWS.

Achieving this action will facilitate maintaining the full extent of occurrence of striped mud turtles in the Lower Keys by identifying all remaining sub-populations so that they can be managed and protected.

Population Size and Demography

Action 7 Survey and monitor Lower Keys mud turtles at all sites known to be inhabited by the species (i.e., 11 islands). Data should be sought to determine population size, demography, recruitment, and survivorship at each site.

Data documenting population size and demography will provide a powerful tool to measure management success as well as to identify threats and population changes. In this regard, repetitive data from a suite of selected sites taken at regular intervals (e.g., every 1 to 2 years) would provide the most valuable comparisons. In contrast, comparison of parameters among different sites is less instructive, given that carrying capacity and demography may vary with habitat and other site characteristics.

Standard methods for determining population size and demography of aquatic turtle populations are extremely time- and labor-intensive. In fact, techniques that rely on trapping and hand-capture may take years to produce robust results. Nonetheless, mud turtles readily enter baited hoop traps and potentially can be monitored more effectively than many other freshwater turtles. For mud turtles, trap size and mesh size need to be scaled to accommodate the small body size of these turtles. By repeating such surveys at the same locales on a regular basis (e.g., annual to biennial), some idea can be garnered as to whether any populations seem to be undergoing substantial declines or increases. Any multi-year data suggesting substantial declines should prompt further investigation for potential causative agents. One unknown factor that may complicate interpretation is whether individual turtles become trap-shy (or trap-happy); this merits investigation.

All trapping surveys should record effort, with sizes and sexes or age classes as can be determined. These can be compared to those available from other studies if available, and perhaps more importantly, across time within sites. They can also reveal evidence of recruitment.

Multi-year monitoring of known nesting sites (for nests or nesting females) potentially can provide important clues to any population trends that may be occurring locally. However, this is probably difficult due to the inconspicuousness of these tiny turtles on land, as well as to the species' potentially long nesting season. Although nests destroyed by predators may be identifiable for months if the brittle eggshells are left on site, relying upon counts of depredated nests alone may be misleading in that it may relate to predator density rather than nest density.

Achieving this action will facilitate maintaining viable populations of the Lower Keys mud turtle by ensuring that species and habitat management regimes are increasing or at least maintaining population densities, and if not, by directing their alteration.

Action 8 Develop a long-term monitoring strategy for the Lower Keys mud turtle.

Over the long-term, it will be critical to periodically re-assess the status of identified populations of striped mud turtles and their habitat to determine if conservation strategies are working and whether other conservation actions need to be taken to mitigate for new or expanding threats. An evaluation of suitable habitat for this turtle should be conducted on a 10-year timeframe to assess changes in habitat quality or quantity and to determine if changes in land ownership or land use are having an effect on the viability of the species. Population monitoring surveys (if feasible) should also be conducted to determine if these strategies are providing conservation benefits for the species.

Action 9 Research the reproductive biology of striped mud turtles in the Lower Keys.

Knowledge of reproduction of this species in the Florida Keys is inadequate. Basic studies of nest site selection, fecundity, periods of nesting and emergence of hatchlings, offspring sex ratios, and survivorship are needed to inform management of the species, specifically the effects of management regimes on reproduction and recruitment. Achieving this action will facilitate maintaining viable populations of the Lower Keys mud turtle by assuring that species and habitat management regimes are facilitating reproduction and recruitment, and if not, by directing their alteration.

Disease and Mortality

Action 10 Establish a mechanism to receive, evaluate, and potentially investigate reports of mortality of this species.

All mortality of Lower Keys mud turtles should be recorded. Typically this will consist of randomly discovered shells, skulls, or (rarely) dead individuals. Unusually high levels of mortality can occur naturally in some turtles as a result of predation (e.g., Jackson and Walker 1997; D. Jackson, FWC, unpublished data), and this can be exacerbated by environmental conditions such as drought (D. Jackson, unpublished data). More significantly, unexplained mortality events warrant immediate investigation.

Any sign of disease in multiple animals within a local population of mud turtles is a matter of concern and should be investigated and monitored. Initial reports should be called to the immediate attention of FWC's Amphibian and Reptile Taxa Coordinator, who should seek input from wildlife veterinarians. Capture of specimens and their examination by qualified veterinarians are advisable. All precautions should be taken when handling and transporting specimens to reduce risk of cross-contamination. Wild populations from which diseased specimens are observed or sampled should be closely monitored to determine whether such disease is isolated or appears to be spreading within the population.

Achieving this action will facilitate maintaining viable populations of the Lower Keys mud turtle by ensuring that any phenomena that might cause further declines of already-small populations are addressed in as timely a manner as possible with a goal of preventing catastrophic losses that could reduce the species' extent of occurrence.

Systematics and Taxonomy

Action 11 Conduct additional taxonomic studies with a substantial genetic-molecular component to examine relationships among mud turtles in the Lower Keys, Upper Keys, Florida peninsula, Florida Panhandle, and elsewhere.

Whether the disjunct, isolated populations of mud turtles in the Lower Keys are distinct in any way from striped mud turtles elsewhere, including the Middle and Upper Keys and peninsula, is a topic of considerable debate (Dunson 1992, Wilson et al. 2006). Older studies (Iverson 1978, Lamb and Lovich 1990, Karl and Wilson 2001) that failed to find significant differences did not have the benefit of current techniques useful for making such comparisons. Therefore, it is important that additional taxonomic studies employing a substantial genetic or molecular component be conducted to examine relationships among mud turtles in the Lower Keys, Middle Keys, Upper Keys, Florida peninsula, Florida Panhandle, and elsewhere. Pending results, it may be appropriate to revisit FWC's recommendation to delist the species. Implementing this action will facilitate maintaining viable populations of striped mud turtles in the Florida Keys and statewide by identifying conservation management units that merit specific management attention to prevent loss of genetic diversity.

Rule and Permitting Intent

Action 12 Maintain current rules that prohibit take (including eggs) of Lower Keys striped mud turtles, except as authorized by FWC permit.

Action 13 Publish freshwater turtle rules annually in FWC fishing handbooks, both in hard copy and online.

The FWC's 2009 freshwater turtle rules (see [Conservation History](#)) limited take and transportation of freshwater turtles within the state. Delayed maturity and high mortality rates of most life stages prior to adulthood place a premium on maintaining large populations of adults. Potential removal of the Lower Keys mud turtle from the Florida Endangered and Threatened Species List further underscores the need to retain the prohibition on take, given that most local populations already are small and likely to decline with the loss of even a few adults. Thus, maintaining a closure on take is by far the most practical management option and hence is recommended by this plan.

Scientific study is a legitimate endeavor that may necessitate take to produce otherwise unobtainable results. Requests for Scientific Collection Permits to allow such take, as authorized under Rule 68A-9.002, F.A.C., must be carefully evaluated on a case-by-case basis. For species of conservation concern, such as the Lower Keys mud turtle, take should be limited to the lowest number of individuals necessary to achieve the stated objectives, as well as to life stages that have the least impact on recruitment into the adult population (e.g., eggs or hatchlings rather than adult females). Local population sizes should also be considered, with large populations better able to withstand low levels of take than smaller ones.

Achieving this action will facilitate maintaining viable populations of the Lower Keys mud turtle by helping to prevent further declines of already-small populations.

Law Enforcement

Although habitat conservation and management are major keys to conserving and managing this species, enforcement of appropriate wildlife regulations remains essential to maintaining viable to robust populations of Lower Keys mud turtles. Responsibility for this enforcement lies chiefly with the FWC in conjunction with agencies and organizations that manage lands to conserve the species' habitat ([Table 1](#)).

Action 14 Develop and implement a training program for FWC law enforcement officers on the identification of and rules and regulations pertaining to protection of striped mud turtles in the Lower Keys.

The FWC's Division of Law Enforcement, in conjunction with federal, state, and local partners, is responsible for enforcing Florida's wildlife and fisheries laws. FWC's law enforcement officers are vital to the success of achieving the goals and objectives of this and other management plans because they both ensure the enforcement of conservation laws and educate the public on how to identify and report violations. FWC staff will provide adequate training to FWC law enforcement officers to ensure that they are able to accurately identify Florida's protected turtles, are aware of all applicable rules and regulations pertaining to these species, and are able to explain to the public the ecological importance of Florida's turtles.

Within the Florida Keys, it is essential that all law enforcement officers, including those from agencies besides the FWC (e.g., USFWS), be knowledgeable about this turtle and able to identify it. Although it is the only native kinosternid turtle in the Florida Keys, there is always a possibility that other species could be released there, so positive identification is important. In conjunction with learning to identify turtles, law enforcement staff should also be encouraged to watch for and report potential threats that they may observe pertinent to this species and its wetland habitats. Achieving these actions will facilitate maintaining viable populations of the Lower Keys mud turtle by helping to prevent further declines of already-small populations.

Incentives and Influencing

FWC administers incentive programs that encourage private landowners to conserve habitat, including hydrology and water quality of wetlands within their properties, for wildlife,. Though not specifically directed toward turtles, and hence not elaborated upon here, such programs undoubtedly can provide important benefits toward Lower Keys mud turtle conservation and hence merit support and the expenditure of resources.

Education and Outreach

Action 15 Develop education and outreach materials for local governments, state and federal agencies, landowners, and the general public to inform them of the habitat needs and conservation measures that can benefit the Lower Keys mud turtle. In conjunction, develop and maintain a web page that contains popular, scientific, legal, and permitting information for all species, including recognized subspecies, of Florida freshwater turtles.

Action 16 Install educational kiosks and regulatory signage at sites where the public is likely to access Lower Keys mud turtle habitat. Mud turtles regularly wander over land and cross roads, often with fatal results, so it is especially critical that roads be strategically posted as well.

Turtles are largely popular with the public, and especially with those who find recreational opportunities within Florida’s natural ecosystems. As such, any materials or activities that provide educational information about turtles, including the Lower Keys striped mud turtle, to those who visit natural habitats in the Lower Keys are likely to be appreciated and in turn, generate support for turtle conservation. Kiosks, signage, and brochures can include information about the striped mud turtle of the Lower Keys, the species’ very limited distribution, and threats to its existence. To date, public agencies have not capitalized on this opportunity. One way to address this may be for the FWC to offer information, expertise, simple publications (pamphlets and brochures), and even direct assistance to land management agencies in the Lower Keys. Additional opportunities to disseminate information about imperiled freshwater turtles exist in schools, environmental centers, and at special events (e.g., wildlife festivals). Although staff from the FWC and other agencies may give presentations or assistance to such groups, this role could be expanded with greater agency encouragement and allocation of additional resources, even to the point of hiring personnel specifically to coordinate and conduct such activities (in conjunction with other imperiled species). Implementing Outreach and Education actions will facilitate maintaining viable populations of the Lower Keys striped mud turtle by helping to prevent further declines of already-small populations.

Coordination with Other Entities

There are many organizations that play essential roles in the conservation of the Lower Keys population of striped mud turtles. Many of these are landowners or managers such as the U.S. Navy, USFWS, FWC, the City of Key West, and the Nature Conservancy. Principal entities, with some of their key roles, include but are not limited to the following:

- DEP: water quality, including OFWs; land conservation
- FWC Invasive Plant Management section: invasive plants
- FNAI: data management, species distribution and occurrence
- Monroe County: wetland conservation
- South Florida Water Management District (SFWMD): wetland conservation
- U.S. Environmental Protection Agency: water quality

South Florida Water Management District

Of the many agencies identified as potential partners in this plan, the role of the SFWMD is integral to habitat conservation and the quality of fresh waters within the Florida Keys. Details about the district’s roles and resources are available at <http://www.sfwmd.gov>. Although the state’s water management districts once operated discrete programs for land acquisition (e.g., Save Our Rivers), most recent land acquisition has been accomplished through the state’s Florida Forever program; nonetheless, the SFWMD still identifies lands beyond this for potential acquisition. In large part because of budget constraints, funding for the Florida Forever program has been substantially reduced since the 2008-2009 fiscal year.

Private Sector

Should establishment of assurance colonies eventually be deemed appropriate, opportunity exists to coordinate with a large private sector devoted to turtle breeding. As one example, the [Turtle Survival Alliance](#), a non-profit organization dedicated to conservation of all of the world's species of turtles through both *in situ* conservation and *ex situ* measures, may be willing to assist in development of such a program.

Table 2. Lower Keys Population of the Striped Mud Turtle (*Kinosternon baurii*) Conservation Action Table

NOTE: An explanation of acronyms used is below the table.

Objective(s) Addressed	Team Assigned Priority Level	Action Item Number	Action Items	Conservation Action Category	Ongoing, Expanded or New Effort?	Authority	Man Power	Estimated Cost To Implement	Funding Source(s)	Lead for Implementation: FWC Program(s) and/or Section(s)	External partners	Likely Effectiveness	Feasibility	Urgent?
1,2	2	1	Identify current conservation lands and privately-owned potential conservation lands that support Lower Keys mud turtles or their habitats and which merit protection and conservation attention for this species.	Habitat Conservation & Mgmt	EXPANDED	YES	YES	TBD	Existing budget	HSC	DEP through its administration of the Florida Forever program; FNAI	Some progress likely.	Practical, but insufficient funding is likely to become available to complete the acquisition portion of the task. However, every acre or mile of river frontage protected is partial success.	No, not critical to striped mud turtles' immediate survival.
1,2	1	2	Maintain or enhance water quality and quantity in all freshwater and slightly brackish wetlands in the Lower Keys.	Habitat Conservation & Mgmt	ONGOING	NO	NO	TBD	Existing budget	HSC	Likely would entail a multi-agency approach including DEP and USFWS	Some actions likely, others highly uncertain.	Maintaining mosquito ditches and freshwater wetlands will be the most urgent need.	Yes. Maintaining wetlands is critical to the survival of the Keys striped mud turtle.
1,2	2	3	Identify and maintain Lower Keys mud turtle nesting and aestivation sites associated with wetlands occupied by the species.	Monitoring & Research	NEW	YES	NO	\$25-50k	Unknown, Grant	HSC, FWRI	DEP, USFWS	Likely.	Practical, feasible.	No, not critical to striped mud turtles' immediate survival.
1,2	1	4	Where high levels of predation (on nests or turtles) are documented, especially on managed conservation lands, institute and maintain appropriate measures to reduce predation. These may include various means of predator control, but also various forms of habitat management.	Habitat Conservation & Mgmt	EXPANDED	NO	NO	\$25-50k	Unknown, Grant	HSC	DEP, USFWS	Likely.	Feasible but will take government commitment and cooperation.	No, not critical to striped mud turtles' immediate survival.
1,2	4	5	Identify the occurrence of any non-native species within the historic range that may affect the habitat, including forage, of Lower Keys mud turtles. Determine effects of these non-native species on mud turtles.	Habitat Conservation & Mgmt	ONGOING	YES	YES	TBD	Unknown, Grant	HSC	DEP, USFWS	Moderate: Invasive exotics are difficult to manage.	Exotics can be managed and partnerships exist, but management is unlikely to reverse the problem.	No, not critical to striped mud turtles' immediate survival.
2	3	6	Survey and monitor Lower Keys mud turtle microdistribution, including wetlands and ditches where the species is not yet documented but where its occurrence might be anticipated based on known range and presence of suitable habitat.	Monitoring & Research	NEW	YES	YES	\$50-100k	Unknown, Grant	FWRI	DEP, USFWS	Likely.	Practical.	No, not critical to striped mud turtles' immediate survival, but for habitat management to be effective, this is needed.
2	3	7	Survey and monitor Lower Keys mud turtles at all sites known to be inhabited by the species (i.e., 11 islands). Data should be sought to determine population size, demography, recruitment, and survivorship at each site.	Monitoring & Research	NEW	NO	NO	\$50-100k	Unknown, Grant	FWRI	DEP, USFWS	Likely.	Practical.	No, not critical to striped mud turtles' immediate survival.
2	3	8	Develop a long-term monitoring strategy for the Lower Keys mud turtle.				NO	TBD	Existing budget	HSC, FWRI	DEP, USFWS	Likely.	Practical.	No, not critical to striped mud turtles' immediate survival.
1	2	9	Research the reproductive biology of striped mud turtles in the Lower Keys.	Monitoring & Research	NEW	YES	NO	TBD	Unknown, Grant	FWRI	DEP, USFWS	Highly likely.	Feasible.	No. Although the research is needed to fill data gaps in our understanding of this population, the research is not needed to alleviate dire threats.
1,2	3	10	Establish a mechanism to receive, evaluate, and potentially investigate reports of mortality of this species.	Monitoring & Research	NEW	YES	NO	TBD	Unknown, Grant	HSC	DEP, USFWS	Likely.	Practical.	No. Although the research is needed to fill data gaps in our understanding of this population, the research is not needed to alleviate dire threats.
1,2	2	11	Conduct additional taxonomic studies with a substantial genetic-molecular component to examine relationships among mud turtles in the Lower Keys, Upper Keys, Florida peninsula, Florida Panhandle, and elsewhere.	Monitoring & Research	NEW	YES	NO	\$25-50k	Unknown, Grant	FWRI	DEP, USFWS	Likely.	Highly feasible.	No. Although the research is needed to fill data gaps in our understanding of this population, the research is not needed to alleviate dire threats.
1	2	12	Maintain current rules that prohibit take (including eggs) of Lower Keys striped mud turtles, except as authorized by FWC permit.	Protections & Permitting	ONGOING	YES	YES	\$0-25k	Existing budget	HSC	DEP, USFWS	Likely.	Highly feasible.	No. Although the research is needed to fill data gaps in our understanding of this population, the research is not needed to alleviate dire threats.

Table 2. Lower Keys Population of the Striped Mud Turtle (*Kinosternon baurii*) Conservation Action Table

Objective(s) Addressed	Team Assigned Priority Level	Action Item Number	Action Items	Conservation Action Category	Ongoing, Expanded or New Effort?	Authority	Man Power	Estimated Cost To Implement	Funding Source(s)	Lead for Implementation: FWC Program(s) and/or Section(s)	External partners	Likely Effectiveness	Feasibility	Urgent?
1,2	1	13	Publish freshwater turtle rules annually in FWC fishing handbooks, both in hard copy and online.	Protections & Permitting	ONGOING	YES	YES	\$0-25k	Existing budget	FFM, HGM	DEP, DOACS, NFWFMD, SFWMD, commercial pet trade	Highly likely.	Fully practical, already being done.	No, not critical to striped mud turtles' immediate survival.
2	2	14	Develop and implement a training program for FWC law enforcement officers on the identification of and rules and regulations pertaining to protection of striped mud turtles in the Lower Keys.	Population Mgmt, Protections & Permitting	ONGOING	YES	YES	\$0-25k	Existing budget	Law Enforcement	Local government	Likely.	Feasible.	No, not critical to striped mud turtles' immediate survival
1,2	2	15	Develop education and outreach materials for local governments, state and federal agencies, landowners, and the general public to inform them of the habitat needs and conservation measures that can benefit the Lower Keys mud turtle. In conjunction, develop and maintain a web page that contains popular, scientific, legal, and permitting information for all species, including recognized subspecies, of Florida freshwater turtles.	Law Enforcement	ONGOING	YES	YES	\$0-25k	Existing budget	HSC, OPAWVS	DEP, USFWS	Highly likely.	Highly feasible.	No, not critical to striped mud turtles' immediate survival.
1,2	2	16	Install educational kiosks and regulatory signage at sites where the public is likely to access Lower Keys mud turtle habitat. Mud turtles regularly wander over land and cross roads, often with fatal results, so it is especially critical that roads be strategically posted as well.	Education & Outreach	NEW	YES	YES	\$0-25k	Existing budget or Grant	HSC, OPAWVS	DEP, USFWS	Highly likely.	Highly feasible.	No, not critical to striped mud turtles' immediate survival.

Acronyms used in this table:

- DEP: Florida Department of Environmental Protection
- DOACS: Florida Department of Agricultural and Consumer Services
- FFM: Freshwater Fisheries Management, a Division of the Florida Fish and Wildlife Conservation Commission
- FNAI: Florida Natural Areas Inventory
- FWC: Florida Fish and Wildlife Conservation Commission
- FWRI: Fish and Wildlife Research Institute, the research branch of the Florida Fish and Wildlife Conservation Commission
- HGM: Hunting and Game Management, a Division of the Florida Fish and Wildlife Conservation Commission
- HSC: Habitat and Species Conservation, a Division of the Florida Fish and Wildlife Conservation Commission
- NFWFMD: Northwest Florida Water Management District
- OPAWVS: Office of Public Access and Wildlife Viewing Services, administered by the Florida Fish and Wildlife Conservation Commission
- SFWMD: South Florida Water Management District
- TNC: The Nature Conservancy
- USFWS: United States Fish and Wildlife Service

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