Species Status Assessment Report for the Florida Keys Mole Skink (*Plestiodon egregius egregius*) Version 1.1

Florida Keys mole skink from Long Beach, Big Pine Key, Florida.
Photo by Adam Emerick, U.S. Fish and Wildlife Service

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Species Status Assessment Report for the
Florida Keys Mole Skink (*Plestiodon egregius egregius*)

EXECUTIVE SUMMARY

The Species Status Assessment (SSA) reports the results of the comprehensive status review for the Florida (FL) Keys mole skink (*Plestiodon egregius egregius)*. For the purpose of this assessment, we generally define viability as the ability of the FL Keys mole skink to sustain resilient populations in the natural coastal ecosystems within the FL Keys over time. Using the SSA framework, we consider what the subspecies needs to maintain viability by characterizing the status of the subspecies in terms of its resiliency, redundancy, and representation (USFWS 2016a, entire; Wolf et al. 2015, entire). This SSA Report provides a thorough assessment of biology and natural history and assesses demographic risks, stressors, and limiting factors in the context of determining the viability and risk of extinction for the species. This process used the best available information to characterize viability as the ability of a subspecies to sustain populations in the wild over time.

The FL Keys mole skink is a small lizard subspecies isolated from the mainland and limited to islands of the Florida Keys. This subspecies is semi-fossorial (adapted to digging and living underground) and cryptic in nature. The FL Keys mole skink occurs in the beach berm and coastal hammock habitats; relies on dry, unconsolidated soils for movement, cover, and nesting; and needs detritus, leaves, wrack, and other ground cover for shelter, temperature regulation, and food (insects found in ground cover).

Focused studies at the population scale have not yet been performed on this subspecies. Due to the lack of specific information on population demographics, the most influential factors used for defining population resiliency for the FL Keys mole skink are coastal beach and hammock habitat; unconsolidated, dry soils; ground cover/leaf litter, debris, or wrack; and arthropods/insects food source.

Preliminary genetic research on the five Florida mole skink subspecies, including the FL Keys mole skink, has recently identified at least four genetically- distinct populations within the FL Keys mole skink subspecies (Parkinson et al. 2016). The preliminary genetic evidence suggests that little to no breeding is taking place between the four genetically differentiated populations, suggesting that the population structure of the subspecies is that of discrete, minimally- to non-interbreeding populations. At this time, an inference cannot be made that these are the only populations or that individuals from these four identified populations only occur on these islands alone (Mercier, K. pers. comm.2017b).

The primary stressors affecting the future condition of the FL Keys mole skink is sea level rise (SLR) and associated climate change shifts in rainfall, temperature and storm intensities, and human development. These stressors account for indirect and direct effects at some level to all life stages and the habitat and soils across the subspecies' range. Other stressors identified are displacement or disturbance from human activities (tourism, beach cleaning); change in habitat characteristics from invasive species (vegetative); displacement or removal by predators (primarily fire ants and feral cats); stochastic events (high tidal inundation from storm surge; oil

spills); pesticides (primarily mosquito prevention spraying); disturbance/destruction of habitat from off-road recreation vehicles (ORVs); dumping; and collection.

The FL Keys mole skink has limited genetic and environmental variation (representation) within the Keys. The subspecies lives in this limited ecological setting, and there is no behavioral or morphological variation within the subspecies. Current searching has documented the subspecies from Long Key southwest to the Marquesas Keys, but no current records have been documented as far west as historical records on the Dry Tortugas or in the Upper Keys in the Key Largo area. Current distribution is only known from where current surveys are taking place. Therefore, there are data gaps on the subspecies' actual range-wide distribution and abundance. Despite the subspecies distribution across many Keys, it needs to be remembered that the overall distribution (redundancy) for this subspecies only occurs within the FL Keys. The FL Keys mole skink is a narrow-ranging endemic.

There are four identified populations and additional individuals (not yet identified into populations) occurring across separate Keys; however, little information exists on the abundance or growth rate of these populations (resiliency). Observation data indicates low numbers within populations. The largest and most consistently surveyed area, Long Beach on Big Pine Key, indicates that all life stages and breeding and nesting are occurring in this area. Populations or low numbers of individuals across the Keys have persisted through many hurricanes and severe storms that are part of this tropical ecosystem. Although available suitable habitat and soils that offer cover, nesting habitat, and food sources for the skinks exist across the range of the Keys, the FL Keys mole skink is still experiencing stressors from SLR, storms and flooding, and development across its range.

The current and ongoing climate change stressors are the most influential threat to the subspecies future condition and status (Pearson et al. 2014, p. 217). To examine the potential future condition of the FL Keys mole skink, three future scenarios were developed. The scenarios focus on a range of conditions based on climate change scenarios and projections for land development. The range of what is likely to happen in each scenario will be described based on the current condition and how resilience, representation, and redundancy would be expected to change. The levels of certainty or uncertainty are addressed in each scenario.

Three feasible future scenarios representing Best, Moderate, and Worst case scenarios for the FL Keys mole skink followed the Low, Medium, and High regional climate change SLR projections, respectively, as developed by the University of Florida under their Geoplan project. Also, for all three future scenarios, the Intergovernmental Panel on Climate Change's description and likelihood of occurrence in the 21st century of extreme weather and climate events including changes in temperature, precipitation, and storm intensity was used (IPCC 2013, p. 7). These projections do not yet reflect National Oceanic and Atmospheric Administration modeling based on new increased SLR rate estimates (which are approximately 15% higher) (NOAA 2017b, entire).

The subspecies future condition is most influenced by the unmanaged and persistent upward trend in SLR. The observed trend in SLR is currently meeting the high SLR curve projected in the 2009 models, and the rate of SLR is also now found to be accelerating (NOAA 2017b, p. 25;

Carter et al. 2014, pp. 401-403; Park and Sweet 2015, entire). At this time, any global management actions currently in place towards the control of GHG emissions will not curb or reverse the ongoing trend. Even if stringent and immediate reductions in GHG emissions were underway, there is still a lag in response such that there is 100 percent chance of exceeding the SLR projected under the current “Low” (best case) scenarios (NOAA 2017b, p. 33).

Approximately 20 percent of the suitable sandy soils are projected to be inundated with 0.13m (5 in) of SLR (the 2040 Low SLR curve and best case scenario). As well, the land mass reduction across the range would create reduced availability of land mass (smaller islands). Loss of land would precipitate an increase in resource competition with people and other animals. Abundance numbers are likely to decrease according to the severity of inundation and loss of habitat and soils. Even in the low SLR curve (best case scenario), a loss of about 10 percent of the suitable habitat and 32 percent of the unconsolidated soils for the FL Keys mole skink are projected to be loss to inundation. This scenario is imminent according to the projections, current trend and lack of intervening management actions (NOAA 2017b, p. 21).

Habitat loss occurs exponentially across the Low, Medium and High SLR scenarios. At 0.13 m (5 in) of SLR, approximately two percent of coastal hammock and beach berm habitat can be expected to be inundated (and thirteen percent of all of the Keys land mass). By 0.3 m (1 ft.) of inundation, 11 percent of the skinks’ suitable habitat (and 24 percent of all of the Keys land) is projected to be inundated. A 0.63 m (2 ft.) inundation (2060 High SLR and worst case scenario) impacts 44 percent of the suitable mole skink habitat (37 percent of all of the Keys land). Even if the population and development pressure decreases as land mass decreases (best case scenario), SLR will still produce loss of habitat and soils for the skink. This loss and consequent fragmentation of habitat is expected to decrease population size (Dubey and Shine 2010, p. 886). As mentioned, the worse-case scenario has an approximately 0.5 to 1.0 percent chance of being exceeded by 2100 according to the present models (NOAA 2017b, p. 21). This low occurrence probability is based on the uncertainty of what will occur in the future as SLR is projected to reach a tipping point and rapidly accelerate.

Given the subspecies’ current condition (3Rs) and the impacts that the subspecies is expected to experience under the future scenarios, reductions in population resiliency, subspecies redundancy, and subspecies representation are expected (Table ES-1).

Table ES-1. FL Keys mole skink population resilience, subspecies redundancy, and subspecies representation under future scenarios.

Population Resilience	**Subspecies Redundancy**	**Subspecies Representation**
Reduced resiliency expected to occur across all future scenarios. The level of reduced resiliency becomes a matter of scale in timing and intensity of SLR. Reduction or loss of suitable habitat and dry soils are main reason for reduced skink abundance and population resiliency under future scenarios. Abundance numbers are low; expected to remain low or become reduced. High variations between islands exist in the projected inundation levels and timing of inundations to beach habitat and lower elevations. When ground cover is washed out, the insect abundance may decrease. When ground cover is washed out, the ability for skink to find cover, nest, and forage is reduced or compromised. The extent and duration of this impact is based on increases to flooding and storm surge and the rate of SLR.	Reduced redundancy expected with all scenarios. Generally expect loss of habitat and inundation impacting areas in the Lower Keys prior to the Upper Keys. No current observations or captures of skinks in the Upper Keys. Generally, larger islands retain habitat longer than smaller ones. Not at all times the case: Big Pine Key is a larger island in Middle Keys that inundates earlier and to a greater extent than some of the smaller islands in that area. A level of redundancy is retained because of the existence of the protected and conversation lands across the range. Although these habitats will be impacted by loss due to inundations. Shifts in vegetation from drier hammock and beach to tidal vegetation will be expected to reduce the quality and quantity of suitable habitat as SLR continues. Greater storm surge – overwash – is expected to reduce redundancy. Increased occurrence of storm surge and floods with increasing inundations is expected to reduce redundancy as occupied areas become flooded. There will be a decrease in recovery time for habitat and populations from the impacts of hurricanes and strong storms as storm intensity and occurrence of storms increases as predicted. Expect loss of populations and further loss of connectivity. Decreased ability to reach new island if passively rafting.	Current condition of low genetic and environmental diversity. Little breadth to rely on if some lost. Not a large difference in habitat types and elevation. No significant “movement to higher ground.” Any inland movement or movement to drier/higher areas is temporary. Islands of the Keys are surrounded by water so inundation can occur along all locations (not just along a coast). Higher grounds are where the cities and communities are located: Key West, Marathon, Key Largo. Low genetics does not assist in sustainability. If a stressor impacts one, it will likely affect all. Stochastic events: For example drought or long term decrease in precipitation levels causes loss of tropical hammock and/or insect food source. This is likely to be a loss experienced across the range of the Keys. All skinks are susceptible.

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CHAPTER 1 - INTRODUCTION

The Florida (FL) Keys mole skink (*Plestiodon egregius egregius*) is a small lizard subspecies known to occur only on islands in the Florida Keys (Keys). We, the U.S. Fish and Wildlife Service (Service), were petitioned to list the FL Keys mole skink as endangered or threatened under the Endangered Species Act of 1973, as amended (Act), as a part of the 2010 Petition to List 404 Aquatic, Riparian, and Wetland Species from the Southeastern United States by the Center for Biological Diversity (CBD 2010, p.462). In September of 2011, the Service found that the petition presented substantial scientific or commercial information indicating that listing may be warranted for 374 species, including the FL Keys mole skink.

The Species Status Assessment (SSA) framework (USFWS 2016a, entire) is intended to be an in-depth review of the species' biology and threats, an evaluation of its biological status, and an assessment of the resources and conditions needed to maintain long-term viability. The intent is for the SSA Report to be easily updated as new information becomes available and to support all functions of the Endangered Species Program from Candidate Assessment to Listing to Consultations to Recovery. As such, the SSA Report will be a living document that may be used to inform Endangered Species Act decision making, such as listing, recovery, Section 7, Section 10, and reclassification decisions (the former four decision types are only relevant should the species warrant listing under the Act).

Importantly, the SSA Report is not a decisional document by the Service; rather it provides a review of available information strictly related to the biological status of the FL Keys mole skink. The listing decision will be made by the Service after reviewing this document and all relevant laws, regulations, and policies, and the results of a proposed decision will be announced in the Federal Register, with appropriate opportunities for public input.

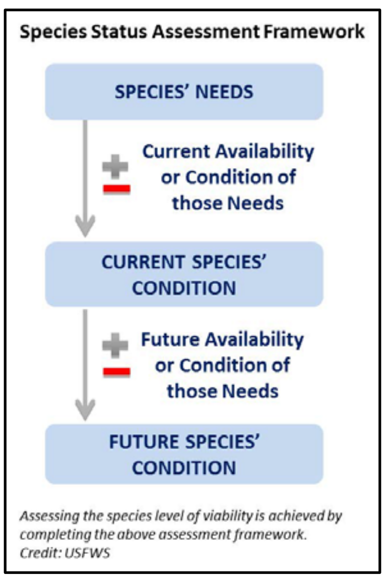


Figure 1-1. Species Status Assessment Framework

For the purpose of this assessment, we generally define viability as the ability of the FL Keys mole skink to sustain resilient populations in the natural coastal ecosystems within the FL Keys over time. Using the SSA framework (Figure 1-1), we consider what the subspecies needs to maintain viability by characterizing the status of the subspecies in terms of its resiliency, redundancy, and representation (USFWS 2016a, entire; Wolf et al. 2015, entire).

- Resiliency is assessed at the level of populations and reflects a species' (or subspecies') ability to withstand stochastic events (events arising from random factors). Demographic measures that reflect population health, such as fecundity, survival, and population size, are the metrics used to evaluate resiliency. Resilient populations are better able to withstand disturbances such as random fluctuations in birth rates (demographic stochasticity), variations in rainfall (environmental stochasticity), and the effects of anthropogenic activities.

- Representation is assessed at the species' (or subspecies') level and characterizes the ability of a species to adapt to changing environmental conditions. Metrics that speak to a species' (or subspecies') adaptive potential, such as genetic and ecological variability, can be used to assess representation. Representation is directly correlated to a species' (or subspecies') ability to adapt to changes (natural or human-caused) in its environment.

- Redundancy is also assessed at the level of the species and reflects a species' (or subspecies') ability to withstand catastrophic events (such as a rare destructive natural event or episode involving many populations). Redundancy is about spreading the risk of such an event across multiple, resilient populations. As such, redundancy can be measured by the number and distribution of resilient populations across the range of the species (or subspecies).

To evaluate the current and future viability of the FL Keys mole skink, we assessed a range of conditions to characterize the subspecies' resiliency, representation, and redundancy (together, the 3Rs). This SSA Report provides a thorough account of known biology and natural history and assesses the risk of threats and limiting factors affecting the future viability of the subspecies.

This SSA Report includes: (1) a description of FL Keys mole skink ecology (Chapter 2); (2) a description of needs at both population and subspecies levels and a characterization of the historic and current distribution of resilient populations across the subspecies' range (Chapter 3); (3) an assessment of the factors that contributed to the current condition of the subspecies and the degree to which various factors influenced viability (Chapter 4); and (4) an assessment and synopsis of the factors characterized in earlier chapters as a means of examining the future biological status of the species (Chapter 5). This document is a compilation of the best available scientific information (and associated uncertainties regarding that information) used to assess the viability of the FL Keys mole skink.

CHAPTER 2 - SUBSPECIES BIOLOGY

In this chapter, we briefly describe basic biological information about the FL Keys mole skink, including its taxonomy, morphological description, genetics, and life history traits such as reproduction, diet, habitat, and distribution. These life history characteristics provide an understanding of the individual needs for the FL Keys mole skink.

2.1 Taxonomy

The FL Keys mole skink (*Plestiodon egregius egregius)* is one of five distinct subspecies of mole skinks in Florida, all in the Genus *Plestiodon* (previously referred to as *Eumeces*) (Brandley et al. 2005, pp. 387-388). The other four subspecies of mole skinks are the northern (*Plestiodon egregius similis*), peninsular (*Plestiodon egregius onocrepis*), blue-tailed (*Plestiodon egregius lividus*), and Cedar Key (*Plestiodon egregius insularis*) mole skinks. The northern mole skink is the most wide-ranging and has been documented in Florida, Alabama, and Georgia. The peninsular mole skink occurs throughout Florida. The blue-tailed mole skink is restricted to the Lake Wales Ridge in central Florida, and the Cedar Key mole skink is restricted to the Cedar Key islands in the Gulf of Mexico (Mount 1968, pp.1-2) (Figure 2-1). Branch et al. (2003, p. 202-205) reported that the FL Keys mole skink is more closely-related genetically to the blue-tailed mole skink than the peninsular mole skink. However, those FL Keys mole skinks in the Upper Keys show morphological characteristics between the FL Keys mole skink and the peninsular (mainland) mole skink (Christman 1992, page 178). Recent genetic evidence supports a lack of interbreeding between the Florida Keys mole skink and the other mole skink subspecies (Parkinson et al. 2016, entire).

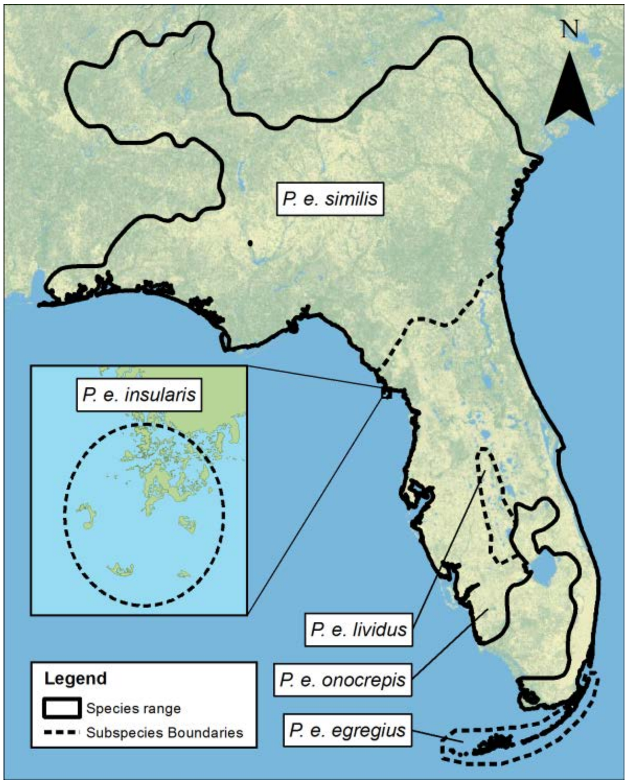


Figure 2-1. Mole skink species and subspecies range (credit: Kathryn Mercier, University of Central Florida 2017).

2.2 Description

The Florida (FL) Keys mole skink (*Plestiodon egregius egregius*) is a small lizard subspecies isolated from the mainland and limited to islands of the Florida Keys (Figure 2-2). This subspecies represents a unique genetic lineage, genetically distinct from the other FL mole skink subspecies (Brandley et al. 2005, pp. 387-388; Parkinson et al. 2016, entire). This skink is a slender, small brownish lizard with a brown, tan, or grey color, smooth, scales and two to four more pairs of light stripes extending from the head and neck that may reach the base of the tail. The tail, as in other subspecies of mole skink, is brilliantly colored; individuals of the FL Keys mole skink captured thus far have shown variations in tail color from orange-red to faded pink. This variation is likely due to age of the animal, as smaller individuals are observed with much more vibrant tails, transitioning to more subdued coloration as they grow. The small legs have five toes on each foot. Males display ventral and submental (under the chin) patches of pink and orange during the breeding season, although hints of these patches can be apparent throughout the year. Adults reach a total length of approximately thirteen centimeters (cm) (five inches (in)) (FNAI 2001, p. 1).

This subspecies is semi-fossorial (adapted to digging and living underground) and cryptic in nature but has also been seen running along the substrate surface when exposed (such as when ground cover is disturbed during searches for skinks). The FL Keys mole skink can run but more often utilizes “swimming” as a method to move through loose substrate. According to Christman (1992, p. 178), “The FL Keys mole skinks seems to occupy intermediate evolutionary position between generalized cursorial (running) skinks and highly specialized fossorial ‘sand swimming’”. The FL Keys mole skinks rely on ground cover over loose substrate as cover and the insects existing in this ground cover as a food source. In this case, “ground cover” as a resource for the Florida Keys mole skink, refers to, “leaf litter, debris, and tidal wrack” rather than a strictly vegetative ground cover such as grass. These ground cover and substrate conditions also provide reproductive and thermoregulatory refugia.

As a reptile, the FL Keys mole skink is a cold-blooded (ectothermic) animal and therefore highly dependent on the air and soil temperature to thermoregulate (maintain body core temperature) (Mount 1963, p. 362). Ground cover moderates soil temperatures and provides shade to assist in the skinks’ thermoregulation in the hot climate. Based on field studies by Mount (1963, p. 363), the optimum temperature range for the mole skink species (*Plestiodon egregius*) is 26 to 34 degrees Celsius(C) (78.8 to 93.2 degrees Fahrenheit [F]) with a mean of 29.5 C (85.1 F). The FL Keys mole skink is specialized to live within this stable and relatively narrow thermal tropical environment. It is a thermoconformer, lacking the capacity to adjust or regulate to changes in temperature outside of this stable and relatively narrow thermal range in which it occurs (Gallagher et al 2015, p. 62).

2.3 Genetics

Preliminary genetics research has been able to identify at least four genetically distinct populations in the FL Keys mole skink subspecies (Parkinson et al. 2016, entire). Currently, the range and abundance of these populations are unknown. The preliminary genetic evidence indicates that there is minimal to no interbreeding or connectivity between these four populations (Parkinson et al. 2016, entire). Individuals of one population have been identified within protected National Wildlife Refuge (NWR) land.

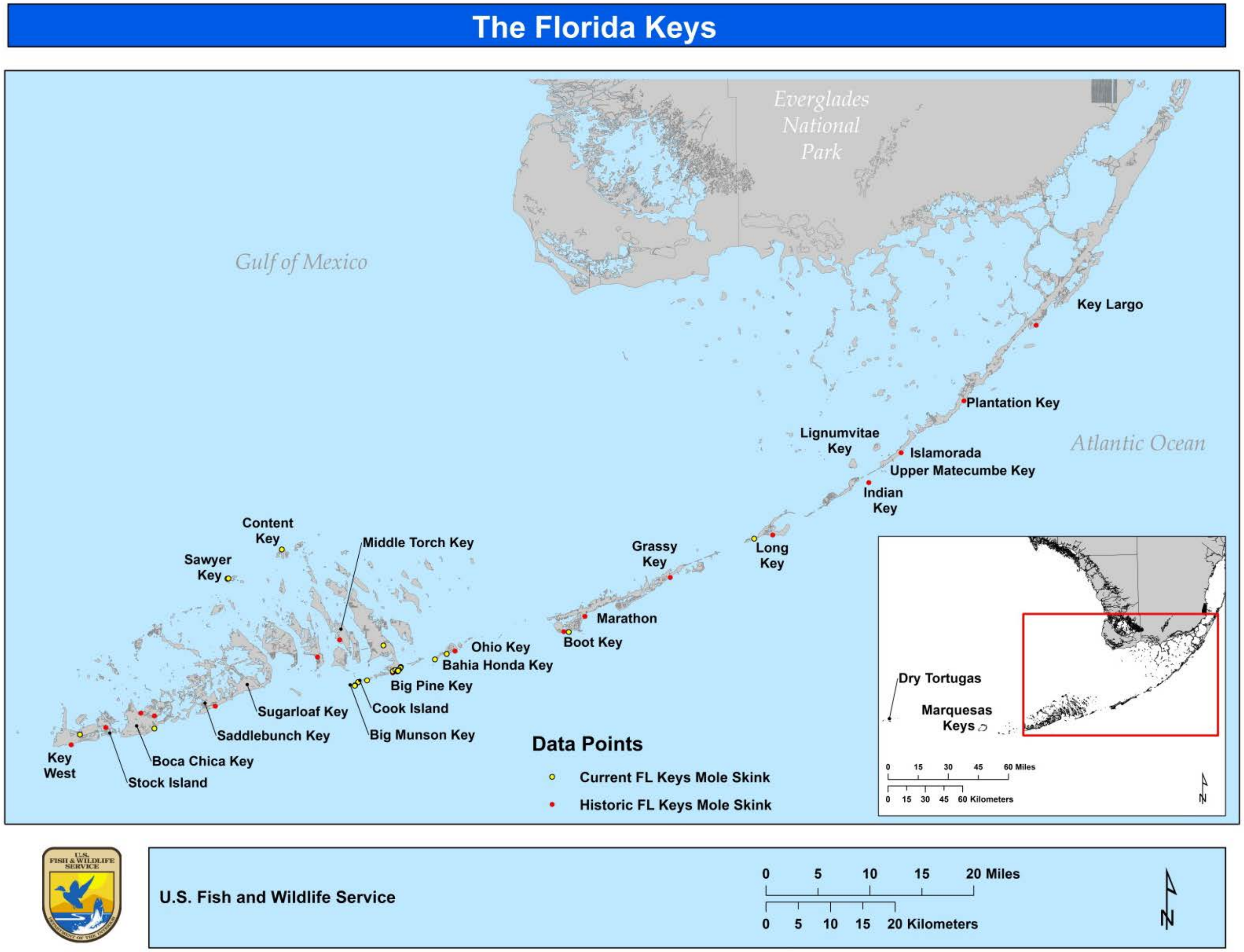


Figure 2-2. The Florida Keys, including inset of the Marquesas Keys and the Dry Tortugas. Data points indicate current and historical observations of Florida Key mole skinks.

2.4 Life History

The FL Keys mole skink has three life stages: eggs, immature (juvenile), and adult. The immature stage lasts approximately one year from hatching to reproductively mature adult. Immature skinks have been found only in beach habitats. It is unknown if this life stage is limited to the beach habitat and these observations may reflect survey bias of the coastal system. The home range of individual skinks is limited (See Section 2.7 Dispersal and Home Range), therefore, where adults are found in areas further inland from the beach habitat, there is a strong likelihood that juveniles are also present (Florida Keys mole skinks Technical Team Working Group [Technical Team Working Group] 2016; Appendix B).

The generation time for the FL Keys mole skink has not yet been documented. McCoy et al. (2010; pp. 641-642) used mark-recapture data with the Florida sand skink (*Plestiodon reynoldsi*) to determine that 60 years represented 15 to 20 generations. This data illustrated that the previous estimate, based on the age at first reproduction, of generation length (30 to 37 generations in sixty years) for the Florida sand skink was underestimated (McCoy et al. 2010, pp. 642-643). The age at first reproduction for the FL Keys mole skink and the Florida sand skink are similar (twenty-four-months compared to nineteen to twenty two months [McCoy 2010, p. 641], respectively) and may suggest a comparable generation time of approximately one generation every three to four years.

The FL Keys mole skink is under-surveyed and little is known about its life history. So the following description of life history is based primarily on red-tailed skink (*Eumeces* [now *Plestiodon*] *egregius*) work conducted in a laboratory setting (Mount 1963, entire). Scent is the most important factor in finding and selecting mates (Mount 1963, p.367). Mating of the mole skink typically takes place in fall or winter. This mating period is observed for the Florida Keys mole skink by field biologists surveying for the subspecies (Technical Team Working Group 2016). After mating the female enters a period of inactivity that last approximately one month (Mount 1963, p. 372). Eggs are laid under debris and usually in nest cavities. Female mole skinks den and attend their nests annually between April and June. The females lick, turn, and protect the eggs from predators. Research has shown that when any of these activities are prevented, the eggs are at risk of not developing normally (Mount 1963, pp. 376-377).

Soils used for nesting are generally dry and unconsolidated to allow for the digging of nest cavities and their “swimming” movement through substrate. Nest depth is probably dependent upon substrate depth and is documented to vary greatly from 0.33 centimeters (cm) (0.13 in) to 1.83 meters (m) (6 ft.) (Hamilton and Pollack 1958, p. 27; Neill 1940, p. 266). Based on laboratory research, an individual skink lays a clutch of two to eleven eggs with an average of three to five eggs (Bartlett and Bartlett 1999, p. 195; Mount 1963, p. 376). Eggs incubate for thirty-one to fifty-one days (Mount 1963, p. 376). No in-situ nests have been identified for the FL Keys mole skink. Because of the predominantly limestone, prehistoric coral reef and rocky makeup of the Keys, only a few areas provide the unconsolidated soils considered preferred by the FL Keys mole skink for nesting. In the Keys, the unconsolidated soil types are predominantly “Beach” and “Bahia Fine sand” and total only approximately 137.6 to 191 ha (340 to 472 ac) of soils in the Keys (Additional information on the distribution of these soil types in the FL Keys is provided in Habitat Section).

In a central FL sandhill scrub habitat, Mount (1965, pp. 372-373) captured more *P. egregius* female skinks with greater regularity than males during February and March and more males than females in November through January. The spring months coincide with a period of heavy foraging by the females (Mount 1963, p. 373). The sex ratio of the FL Keys mole skink is uncertain at this time. The sex ratio for the sand skink is 1:1 (Gianopulos, 2001, p. 23-24; Sutton 1996, p. 36). Recent collections of FL Keys mole skink have indicated a near 1:1 female to male ratio although this sample size is small and sex was not determined for approximately 40 percent of those skinks collected (Table 3-2).

2.5 Diet

The FL Keys mole skink preys on a variety of small insects (Hamilton and Pollack 1958, p. 26; Mount 1963, p. 364; Technical Team Working Group 2016). Hamilton and Pollack (1958, p. 26) examined digestive tracts of 36 *Plestiodon* subspecies including one sample from Key West and found ants, spiders, crickets, beetles, termites, small bugs, mites, butterfly larva, pseudoscorpion, and fungus. The make-up of diets has been shown to shift seasonally with prey relative to abundance. Prey is also thought to be caught and eaten underground (Mount 1963, p.365). The recent surveys and field work by species experts indicate generalist and opportunistic (preying on those insects that are present and are of a size that the skink can ingest) feeding behavior by the FL Keys mole skinks within their ground cover habitat (Technical Team Working Group, 2016; Appendix B).

2.6 Habitat

The FL Keys mole skink has been found in debris, piles of rocks, and wave-washed wrack. They have also been found among rocks a few feet above the water on railroad embankments in the Upper Keys (Carr 1940, p. 75). Individual skinks have also been observed in shaded areas beneath stones in sandy areas of Key West and Stock Island (Duellman and Schwartz 1958, p. 289). The FL Keys mole skink is documented in the beach berm zones and coastal hammocks in the Upper and Middle Keys (FNAI 2011). Individuals require, or highly prefer, loose soils (Christman 1992 p. 179). Loose soils allow for “swimming” mobility through substrate and are conducive to burrowing and nesting. Mount (1963, p. 359) identified the two key ecological factors affecting mole skink distribution as soil and moisture conditions. Mount (1963, p. 359) seldom encountered mole skinks where the soil was not well drained and friable.

The total land mass of the islands of the Keys is approximately 37,859.6 ha (93,553 acres). This includes the lands of Monroe County, Florida - the main islands connected by the Overseas Highway, the Dry Tortugas, Marquesas Keys (36,006.1 ha; 88,973 ac) - as well as the Keys above Key Largo (in Miami-Dade County, Florida)(1853.5 ha; 4580 ac)(Figure 2-2; Table 2-1)(Monroe County 2016; FWC and FNAI 2016). The smaller backwater islands (only accessible by boat) consist approximately of an additional 2596.5 ha (6416 ac). This total land mass value for the backwater islands is only an estimate; these Keys are mainly mangrove, tidal islets. It is a dynamic system with changes in land-cover based on conditions, and therefore, mapping is difficult.

Table 2-1. Total land mass, Florida Keys mole skink a) available suitable habitat types and b) suitable soils across the Florida Keys (Monroe County 2016; Miami-Dade County 2016).

	Total land mass Hectare (h) (acreage(ac))	Suitable habitat for FL Keys mole skink (beach berm; coastal hammock)	Suitable soils for FL Keys mole skink (Bahia Fine Sand/Beach or Unconsolidated substrate)
Florida Keys (Monroe County from Key Largo to Dry Tortugas and Miami-Dade County Keys above Key Largo)	37,859 ha (93,553 ac) 36,006 ha (88,973 ac) from Key Largo to Dry Tortugas; 1853.5 ha (4,580 ac) from Keys above Key Largo in Miami-Dade County)	3682 ha (9,067 ac) (beach berm and coast hammock) 739.4 ha (1,827 ac) (nontidal, beach, coastal upland, hammock, shrub and brushland).*	Approximately 137.6 to 191 ha (340-472 ac) (Key Largo to Dry Tortugas, Monroe County) (the area north of Key Largo in Miami-Dade County is not included)*
Backwater islands	2,596 ha (6416 ac)	Unidentified –but predominantly tidal mangrove	333 ha (823 ac) unconsolidated soils
*"Soils" are not identified separately in Miami-Dade County mapping. The 739.4 ha (1,827 ac) defined as "Suitable habitat" from Miami-Dade mapping incorporates "unconsolidated soils".			

The current total acreage of the beach berm and coastal hammock identified as available suitable habitat in the Keys from Key Largo to the Dry Tortugas is approximately 3682.6 ha (9100 ac) (Table 2-1). The current suitable soils (identified as Bahia Fine Sand, Beach and unconsolidated soils) for this same range total approximately 137.6 to 191 ha (340-472 ac) (U.S. Department of Agriculture 1955, p. 55; Monroe County 2016; Miami-Dade County 2016). Based on the Monroe County Soil maps, unconsolidated (or sandy) soils range in parcel sizes from 1.6 to 29.0 ha (4.0 acres to 72.0 ac)(average 7.8 ha; 19.2 acres) and occur on six of the main Keys in Monroe County: Lower Matecumbe, Long Key, Boot Key, Bahia Honda, Big Pine and Key West (Monroe County 2016)(Table 2-2) .

Due to a lack of available geographic information for habitat types and specific soils, the areas of the backwater islands and north of Key Largo are not included in the acreages for suitable habitat type. Information provided from a separate State of FL land cover map was used to estimate areas of suitable habitat and soil for these areas. In the Keys above Key Largo, approximately 739.4 ha (1827 ac) is identified as coastal hammock habitat and unconsolidated soils (combined). The backwater islands of the Monroe County Keys consists of approximately 334.3 ha (826 ac) of unconsolidated soils (FWC and FNAI 2016).

Table 2-2. Total acreage and locations of mapped unconsolidated dry soils (Bahia Fine Sand and Beach Soils) in Florida Keys, Monroe County.

Florida Keys, Monroe County Bahia Fine Sand and Beach Soils		
Bahia Honda Fine Sands	**Hectare (Acreage)**	**Location**
	13.26 (32.75)	Long Key
	5.75 (14.21)	Long Key
	3.78 (9.34)	Long Key
	4.72 (11.66)	Long Key
	3.96 (9.79)	Long Key
	5.63 (13.91)	Long Key
	6.88 (17.01)	Long Key
	21.07 (52.06)	Boot Key
	28.95 (71.54)	Boot Key
	9.38 (23.18)	Boot Key
	1.85 (4.57)	Boot Key
	16.86 (41.66)	Bahia Honda
	15.14 (37.41)	Big Pine Key
	4.00 (9.89)	Big Pine Key
Total Bahia Honda Fine Sands	141 ha (349 ac) (mean of 10 ha; 25 ac)	
Beach Sands	**Acreage**	**Location**
	2.04 (5.04)	Lower Matecumbe Key
	3.58 (8.85)	Long Key
	1.61 (3.98)	Bahia Honda
	2.41 (5.96)	Bahia Honda
	2.90 (7.16)	Key West
	1.66 (4.11)	Key West
Total Beach Sands	14 ha (35 ac) (mean of 5 ha; 12.3 ac)	
Total unconsolidated, dry soils	Approximately 155 ha (384 ac) unconsolidated soils (total mean of 7.75 ha; 19.2 ac)	

Pockets of unconsolidated soils occur occasionally across the islands as small patches of sand within upland areas and as augmented soils (home gardens). The total amount of these soils is not quantified but account for only a small percentage of the total soil in the subspecies' range. Information is lacking on their use by skinks, particularly for nesting but it is likely these areas are used opportunistically by skinks as adult habitat, and possibly for nesting (Technical Team Working Group 2016). There is a single, verified observation of an adult skink found within a private citizen's back yard in a completely developed area of Key West.

2.7 Dispersal and Home Range

There is a high confidence level among the herpetological experts that juvenile skinks newly establish a territory or home range away from their parents (Technical Team Working Group, 2016). Direct evidence is lacking on the FL Keys mole skink home range distance. Schrey et al. (Schrey et al. 2011, p. 64) showed that sand skinks (*Plestiodon reynoldsi*) that were captured within 25 m (82 ft.) of each other were genetically more similar (statistically significant) than other individuals who were beyond that distance. Because genetic differentiation requires time to become develop, it shows a pattern of behavior in which individuals interbreed within 25 m (82 ft.) of each other. In this study, the maximum distance used for captures in this study was limited to 25 m (82 ft.) (Schrey et al. 2011, p. 60). Mushinsky et al. 2001(p. 55) found that adult female sand skinks had an average dispersal distance of 23 m (75 ft.).

Maximum dispersal distances for sand skinks (*Plestiodon reynoldsi*) in FL scrub habitat have been documented at 35 m (115 ft.) upwards to 140 m (460 ft.) although just a few adults were recorded at distances greater than 100 m (328 ft.) (Gianopulus 2001, p.81; Mushinsky et al., 2001, p. 54). The larger home range distances of a few individual sand skinks beyond 100 m (328 ft.) could be attributed to localized resource limitations or adult “floaters”.

As mentioned, the dispersal distance or typical home range for FL Keys mole skink individuals has not been yet been studied but it is expected that the mole skink home range is similar to that documented for the sand skink. The overall high population structure found in the mole skink (five FL subspecies) also supports limited dispersal for individuals of these subspecies (Branch et al. 2003, p. 2007; Adler et. al. 1995, p. 535). In general, males skinks are expected to have a slightly longer dispersal range than females to search for mates. Female skink dispersal distances are likely lower than the males as they need to have soils for nesting, and remain with the nest.

Home range and maximum dispersal distances have been based on the findings of individual skinks. The total size of an area needed to support a population of skinks has not been defined. Rafting as a dispersal mechanism is known to play a role for immigration/emigration of skinks to new locations or other islands (Adler et al. 1995, p. 535-537; Branch et al. 2003, p. 207). The degree and success to which this mechanism plays on the FL Keys mole skink in establishing new populations on unoccupied islands is uncertain.

2.8 Distribution and Density

Gianopulos (2001, p. 26) found no statistically significant differences in the size distribution of sand skinks (adult versus juvenile) among sites in any given time of the year. However, three to five times more adult than juvenile sand skinks were captured during Spring surveys (February thru March; using pitfall traps) (Gianopulos (2001, p. 24). This result may be a reflection of differences in seasonal reproduction and abundance rather than or in addition to the motility and distribution between the two life stages. It is uncertain if size distributions exist for the FL Keys mole skink.

Density values for the FL Keys mole skink across the landscape are unknown; however the distribution of individuals is not expected to be uniform across the range or even within a localized area of suitable habitat. Also, as an islandic subspecies and based on the historical and current observations the FL Keys mole skink is an uncommon subspecies and its total overall abundance compared to that of the mainland skinks is low.

For the peninsular mole skink (*Plestiodon egregius onocrepis*), one of the mainland subspecies, density values have been documented as high as 62.5 adults per ha (25 per ac) (Christman 1992, p. 120). Notably, however, that even in what was apparently suitable habitat, the mole skink showed limited dispersal and individuals were “concentrated in more localized pockets” (Christman 1992, p. 120; Schrey et al. 2012, pp. 243-244 and245-246). A similar clumped distribution is expected to exist for the FL Keys mole skink. The presumed limited range of individual skinks and the patchy distribution of the suitable habitat across the Keys suggest that there is also a clumped distribution for the FL Keys mole skink subspecies (although in low abundance).

In a comparison of density values, the more common sand skink has an average density of 163 per ha (per 2.5 acre), and individual sand skinks were located 20 times more frequently in field collections than blue tail mole skinks (*Plestiodon egregius lividus*), a rare and related subspecies to the FL Keys mole skink (Christman 2005, p. 12; Christman (1992, p. 120).

CHAPTER 3 - POPULATION AND SUBSPECIES NEEDS

In this chapter, we consider the FL Keys mole skink historical distribution, its current distribution, and the ecological needs at the population and subspecies level. We first review the historical information on the range and distribution of the subspecies. Next, we review the current range and distribution based on recent survey efforts. Then, we evaluate population and subspecies' ecological needs to consider their relevant influence to FL Keys mole skink resiliency, representation, and redundancy.

3.1 Historical Range and Distribution

The FL Keys mole skink has been found in small numbers across the range of the Florida Keys (Keys) (including the Marquesas Keys and Dry Tortugas) (Figure 2-2; Table 3-1). This is an area made up of a low-lying chain of small ancient coral reef islands (Keys) extending southwest from the Florida peninsula. The Keys are primarily mangrove islands comprised of predominantly limestone substrate (ancient coral reef). The Keys consist of approximately 1,700 islands connected by the overseas highway and additional smaller outlying islands. The area covers approximately 360 square kilometers (km^2) (139 square miles [mi^2]) (Zhang et al. 2011, p. 3). The Marquesas and Dry Tortugas are located approximately 35 and 113 km (25 and 70 mi) west of Key West, Florida, respectively. The small Keys of the Marquesas consist of an approximate 6.5 km^2 (2.5 mi^2) land area. The Dry Tortugas islands cover an area of approximately 259 km^2 (100 mi^2). The average elevation of the Keys is less than one meter (3.2 ft.) above sea level. Windley Key in the Upper Keys is identified as having the highest elevation at approximately 5.5 m (18 ft.) above sea level (United States Geological Survey [USGS] South Florida Information Access [SOFIA] 2017; Florida Department of Environmental Protection [FEDP] 2012a, p. 12).

For reference in this document, the FL Keys have been geographically divided into the Upper, Middle, and Lower Keys. The Upper Keys are referred to as the set of Keys from Key Largo to around Grassy Key, in the Middle Keys. The Middle Keys contain The City of Marathon (Knight's Key) down to about Bahia Honda Key. Bahia Honda Key down to Key West constitutes the Lower Keys (Figure 2-2).

Historically, observations of the FL Keys mole skink are documented from Key Largo, Plantation Key, Upper Matecumbe Key, Indian Key, Long Key, Grassy Key, Boot Key, Key Vaca, Saddlebunch, West Summerland Key, Sawyer Key, Bahia Honda, Big Pine Key, Boca Chica, Middle Torch Key, East Rockland Key, Stock Island, Key West, Mooney Harbor (Marquesas) and Dry Tortugas (Florida Museum of Natural History [FLMNH] 2011; Florida Natural Areas Inventory [FNAI] 2011; Mays and Enge 2016, entire; Mount 1965, p. 208) (Table 3-1; Figure 2-2). These historical observations are independent and opportunistic reports. The current and ongoing surveys by the National Key Deer Refuge (Refuge) and the Florida Fish and Wildlife Commission (FWC) will be considered in Section 3.2 Current Range and Distribution.

Table 3-1. Florida Keys mole skink historical observations (prior to 2014.)

Location	Year (number of specimens observed)
Key Largo	1960 (2); 1978 (unknown); 1979 (1); 2013 (1); *unknown* (4)
Plantation Key	1982 (1)
Upper Matecumbe Key	1934-35 (2); 2013 (1)
Indian Key	*unknown* (2)
Grassy Key	1960 (1)
Key Vaca	1983(1)
Boot Key	1988 (1) , 1997 (1) , 2013 (1)
Bahia Honda	1972 (*unknown*); 1980-84 (*unknown*)
Scout Key	mid-80's; (*unknown)*
Big Pine Key	1947 (1); 2012(1); 2014 (1)
Middle Torch Key	1977-1985 (*unknown*)
Saddlebunch Keys*	1993 (>65)*
Stock Island (Key West)	1958-1970 (1); 1960 (1)
Key West *	1934-35 (5); 1960 (7), 1960 (1), 1979 (1), 1983 (1),1993 (>80)*; *unknown* (1)
Dry Tortugas**	1862 (1)**
Unknown location	1938 (1)

*Higher number of specimens reported. Same person reporting; unverified if FL Keys mole skink.
**Museum of Comparative Zoology specimen; Harvard University; unverified.

3.2 Current Range and Distribution Determined From Recent Survey Efforts

A 2015 to 2016 FWC study found individual FL Keys mole skinks under coverboards at Bahia Honda Key (Mays and Enge 2016, entire). Observations were made on Big Pine Key, Boca Chica, Sawyer Key, and Boot Key using raking methods. The Sawyer Key and Boca Chica observations are new records for these islands (Mays and Enge 2016, p. 11; Table 3-2; Figure 2-2). The same survey efforts by FWC during this time failed to record any sightings on the Marquesas islands and the Dry Tortugas, Boca Grande Key, Woman Key, Key West, Content Keys, Upper Sugarloaf Key, Scout Key (once West Summerland), Little Crawl Key, Lower Matecumbe Key, and Tavernier (Mays and Enge 2016, p.11). In June 2015, Refuge staff documented a skink adjacent to a sea turtle nest on Mooney Island in the Marquesas Keys. The most northern recent observation and capture of the FL Keys mole skink is of a single skink on Long Key at Long Key State Park in January 2017. Long Key is approximately 50 km south (39 mi) of Key Largo (Figure 2-2).

A current FL Keys mole skink survey project is underway by Refuge biologists on selected areas of refuge property including Long Beach on Big Pine Key and Ohio Key where suitable beach and coastal habitat occur. Skinks have been historically documented on Long Beach. The predominant capture methods being used are via the use of coverboards or hand search (uncovering them with hand searching or gentle raking of ground cover or debris). The Refuge project focuses on better defining the habitat being used by the skinks as well as collecting life history data on size classes and sex ratio throughout the year. Preliminary findings from the FWC and Refuge work include 127 records from 11 locations (Emerick and FWC 2017; Table 3-2; Figure 2-2).

Table 3-2. Collection data for the Florida Keys mole skink (January 2014 - January 2017). (Preliminary unpublished information from current survey work by Emerick and FWC 2017).

Locations (north to south)	Number of skinks recorded; #/year		Sex (Female/Male/Unknown)
Long Key	1	2017	F
Boot Key**	2	2016	2 unknown
Bahia Honda	5	2016	3 M; 2 unknown
Big Pine; Long Beach*	104	2014 - 6 2015 - 9 2016 - 85 Jan. 2017- 4	30 F 34 M 40 unknown
Cook Island **	1	2017	F
Big Munson**	5	2016 - 3 2017 - 2	1 F 1 M 3 unknown
Content Key**	3	2017 – 3	1 F 1 M 1 unknown
Sawyer Key**	3	2015 -1 2016 – 2	1 F 2 unknown
Boca Chica	1	2015	M
Key West	1	2016	F
Marquesas **	1	2015	unknown
Total	127 observed or captured records		36 F 40 M 51 unknown

* Targeted habitat survey. 74 of 104 counts are verified as "Recaptures" (R) or "Novel (N) (first time captures)". Of 74: 55 (74.3%) = Novel capture; 19 (25.7%) = Recaptures. 30 of 104 = undeterminable as R or N.
**only accessible by boat.

In the preliminary Refuge surveys, 104 observations or captures have been documented at the Long Beach site on Big Pine Key (Table 3-2). Seventy-four of the 104 records at Big Pine Key were able to be verified as either a) first time (novel) captures or b) recaptures. Of these 74 records, approximately 26 percent were recaptures which provides some indication of site fidelity and limited dispersal range at this site (Emerick and FWC 2017; Table 3-2; Figure 2-2). The 26 percent recapture value could be underestimated since 30 of the total 104 samples were not able to be verified as either first time captures or recaptures. An approximate 1:1 ratio of male to female is being observed although the sex was undeterminable for 40 percent of the Long Beach captures (Table 3-2).

The second site specifically being targeted by searches for the FL Keys mole skink is Ohio Key. Ohio Key is a small Key immediately adjacent to Bahia Honda to the northeast (Figure 2-2). There are a total of 25 coverboards on Ohio Key that have been checked a total of 643 times. The coverboards were checked daily between 8am to 1pm during October 2016 through January 2017. Twelve hours of searching at various times of the day also took place and drift fence/pitfalls were checked once a day for three weeks. Although this site was selected because of the existing suitable habitat, there have been zero observations or captures of FL Keys mole skinks at this location. This survey project began in 2016 and is still underway. Sample sizes are small and the findings at this time are only preliminary.

In addition to the monitoring surveys taking place at the Big Pine Key and Ohio Key suitable habitat sites, opportunistic searches for the FL Keys mole skink also occur by Refuge staff at the numerous coverboards in place across the Keys. These coverboards are used in locating various reptile species occurring in the Keys, including the FL Keys mole skink. A summary table of the opportunistic searches is provided in Appendix A. From November 2016 to January 2017, approximately 63 search-hours with predominantly two searchers (on a few occasions, three) at 10 locations throughout the Keys yielded the finding of eight FL Keys mole skinks from four locations. Two locations, Content Key and Big Munson Key, each yielded three skinks (Appendix A).

Herpetologists believe that skinks are likely to still occur as far north as Key Largo in the vicinity of the historical documentations (FL mole skinks Technical Team Working Group [Technical Team Working Group], 2016; Appendix B). However, recent checks of coverboards placed within the Crocodile Lake National Wildlife Refuge on Key Largo have failed to observe or capture skinks within well-developed tropical hardwood hammocks (Emerick pers. comm. 2017a). Additionally, a recent effort in February 2017 (three weeks of daily searching) to collect specimens for genetic samples in Key Largo, a historically documented skink location in the Upper Keys, has failed to observe any skinks (Mercier, K. pers. comm. 2017a). It is important to note that locating and capturing skinks is difficult because of their small size and cryptic nature, and even those persons with experience in locating and capturing skinks have varied success.

While historical records only exist from Key Largo out to the Dry Tortugas, species experts have not formally searched for the subspecies north of Key Largo or in the numerous smaller and remote “backwater” islands to the north in Florida Bay. Species experts agree that while the amount of suitable habitat in these areas is minimal (most of the islets are tidal mangrove), they will not discount the possibility that individuals of the subspecies could currently exist there (Emerick pers. comm. 2017b; Moler pers. comm. 2017).

3.3 Needs of the FL Keys Mole Skink

In order to assess the current and future condition of the subspecies, it is necessary to identify the population and subspecies needs. As defined earlier, resiliency is the ability to withstand disturbances associated with population abundance and demography, genetic diversity, growth rate, and habitat quality (Shaffer and Stein 2000, pp. 305-310). Population resiliency is reflected by the quality of these factors and resources.

3.3.1 Population Needs

As part of the population needs assessment, we first identified and described the most influential factors representing the individual and population needs for the subspecies. The methods used to identify population needs included convening a Technical Team Working Group Workshop

(2016), the use of published literature, unpublished reports, and preliminary (unpublished) data from current survey and taxonomy research projects.

Focused studies at the population scale have not yet been performed on this subspecies. As mentioned, their cryptic nature makes sightings and captures of individual skinks difficult. Current individual counts are biased toward focused survey locations (in the Refuge and state park lands in the Lower Keys). Population abundance, distribution, age classes, or densities cannot be confidently inferred at this time from this preliminary information (Table 3-2). Specific information on population carrying capacity, birth rates, and nesting success is lacking for this subspecies. Previously cited work on the mole skink species has indicated the importance of suitable habitat, ground cover, insect food sources, and unconsolidated dry soils for meeting life history needs (breeding, feeding, cover, movement) of the mole skink. Therefore, due to the lack of specific information on population demographics, population needs and resiliency were assessed primarily through habitat quantity, habitat quality, and food resources. Specifically, the most influential factors identified for defining population resiliency for the FL Keys mole skink are:

- Coastal beach and hammock habitat (as identified in Monroe County mapping);
- Unconsolidated, dry soils, (loose soil substrate as identified in Monroe County mapping as Beach sand and Bahia Honda Fine Sand);
- Ground cover/leaf litter, debris, or wrack; and
- Arthropods/insects food source (found within the ground cover of the habitat).

A quantitative equation for habitat and soils as a surrogate for FL Keys mole skink population size or abundance does not exist, however there is a high level of confidence among experts that as long as there is available suitable habitat and soils, populations are able to be supported in the system (Technical Team Working Group 2016). Considering the cryptic nature and inability to directly and easily observe or locate skinks, suitable habitat and soils are used as a guide for potential presence of the FL Keys mole skink. These habitat metrics will be used as a factor in assessing population resilience. In other words, the amount of suitable habitat or soils on a Key or at a site will not be directly associated to defining population abundance or occurrence. While the presence of suitable habitat and soils provides confidence that skinks are able to occur there, an immediate inference cannot be made that if there is suitable habitat than there will be skinks present. As previously mentioned, Refuge biologists have completed 600 coverboard checks on Ohio Key resulting in no observations of skinks at this location although this site was selected due to existing suitable habitat. The biologist believes that Ohio Key may have been over-washed in the last large hurricane or large storm surge, and if skinks were present, they may have been washed off the Key or killed, and apparently have not recolonized despite the return of suitable habitat (Emerick pers. comm. 2017c). Due to the difficulty in locating the FL Keys mole skink, it is also possible that the searches have not observed skinks that may be present on the Key. The availability of dry and unconsolidated soils (sand) is likely a limiting factor in nesting success for the subspecies across its range. Because these are cryptic and elusive animals, the availability of suitable habitat and soils, in total, is a key factor for assessing population health and persistence of the FL Keys mole skink.

3.3.2 Population Structure

Preliminary taxonomic research on the five Florida mole skink subspecies, including the FL Keys mole skink, has recently identified at least four distinct populations within the FL Keys mole skink subspecies. Skink tail samples were collected from skinks captured during recent surveys of Big Pine Key (19 samples), Boca Chica Key (three samples), Bahia Honda Key (one sample) and Boot Key (one sample) (Parkinson et al. 2016) (Figure 2-2). A discrete genetic signature was identified at each of the four Keys where samples have been processed; additional tail samples collected from other Keys are still to be processed. It is important to note that these are only preliminary findings using very small samples sizes, and these are the only four locations from which samples have been processed. While the confidence level in identifying these populations is high, it is not the full picture of population structure. At this time, an inference cannot be made that these are the only populations or that individuals from these four identified populations only occur on these islands alone. The abundance and extent of these four identified populations are unknown at this time. There are many Keys in which individuals occur that have not been associated with any population, either as members of one of the four identified populations or of any other possible, yet-identified population (Mercier, K. pers. comm.2017b).

The preliminary genetic evidence indicates that little to no breeding is taking place between the four genetically differentiated populations, suggesting that the population structure of the subspecies is that of discrete, minimally- to non-interbreeding populations (Parkinson et al. 2016; Technical Team Working Group 2016; Mercier, K. pers. comm. 2017b). This population structure is supported by the relatively limited dispersal and small home ranges assumed for the FL Keys mole skink.

There is a high likelihood that some level of stochastic passive dispersal of individuals, primarily via rafting (carried by floating debris and seaweed wrack) is occurring (Adler et al. 1995, pp. 535-537; Branch et al. p. 2003 p. 207; Losos and Ricklefs 2010, p. 360). Possible stochastic events leading to rafting or passive movement of skinks include a) inundation and flooding of low-lying areas from strong seasonal storms and hurricanes that move debris or soils, and b) high tides and coastal storm surge that collect and carry wrack and vegetative mat. Distances between the Keys with these identified populations (from north to south) are relatively close: a) approximately 14.5 km (9 mi) from Boot Key, located on the northern end of the overseas highway, to Bahia Honda, the next nearest identified population; b) approximately 9.7 km (6 mi) from Bahia Honda to Big Pine Key; and approximately 25 km (15.5 mi) from Big Pine Key to Boca Chica, the most southern-identified population. Individuals may be dispersing (rafting) from one island to another often enough to maintain some interaction among the populations but still at levels low enough that the populations remain distinct (Cronin, 2003, p.1186; Smith and Green 2005, p.111-113). There are also small islets which lay between these mentioned Keys.

Rafting as a dispersal mechanism is known to play an important role for immigration of individuals to other Keys but the degree and success to which this plays for the FL Keys mole skink in establishing new populations on unoccupied islands is uncertain (Branch et al. p. 2003, p. 207; Adler et al. 1995, p. 535-537). There are numerous Keys in relatively close proximity to one another, so distance is not a huge barrier to reaching new areas. However, successful colonization of an unoccupied island would require a mating pair or a gravid female to reach and become established. The level to which the subspecies can rely on this strategy to assure or even contribute to future persistence is uncertain and believed to be low.

Based on preliminary genetic evidence, the subspecies population structure is a set of multiple, non-interacting populations on separate Keys. Additional information may find that its structure is some form of a classic metapopulation - with population extinctions and recolonization of new immigrants - to the degree that there are interactions (immigration and emigration of individuals) between Keys.

Description of the Keys in which genetically distinct populations have been identified

Boot Key – At approximately 445 ha (1,100 ac) Boot Key is one of the largest privately-owned islands in the Florida Keys. It is located within the City of Marathon, Monroe County, Florida and is largely undeveloped. Suitable habitat for the FL Keys mole skink on Boot Key consists of nearly 8 km (5 mi) of undeveloped shoreline and 7.3 ha (18 ac) of hammock habitat. There are approximately 61.25 ha (151 ac) of sandy soils (Table 2-2). Disturbed areas (road and 4.5 ha (11 ac) developed area on southwest part of the island) make up less than three percent (10.5 ha; 26 acres) of the island.

Big Pine Key – Located in the lower Florida Keys, Big Pine Key is approximately 2693.6 ha (6656 ac). Big Pine Key is situated between the Torch Keys to the west and Boot Key (once named West Summerland Key) to the east. The Refuge consists of approximately 1654 ha (4,087 ac) of Big Pine Key. Available habitat for the FL Keys mole skink on Big Pine Key consists of coastal hammocks and beach shoreline in the Refuge property. There are approximately 19 ha (47 ac) of sandy soils mapped on Big Pine Key (Table 2-2).

Bahia Honda – Bahia Honda is located in the Lower Keys between Ohio Key to the east and Scout Key to the west. At approximately 212 ha (524 ac), Bahia Honda is entirely under the ownership of the Florida Park Service (Bahia Honda State Park). Approximately 21 ha (52 ac) of sandy soils occur on Bahia Honda (Table 2-2). While development is limited, there is high recreation use on the island.

Boca Chica Key – Located approximately 6 km (3.7 mi) east of Key West, Boca Chica Key is approximately 1717 ha (4243 ac) in size. This island is under federal ownership by the Naval Air Station Key West and the Great White Heron National Wildlife Refuge. The island holds an existing two-runway airstrip. It is highly developed and undeveloped areas are generally tidal, but some upland areas occur that provide habitat and dry unconsolidated soils for the FL Keys mole skink.

3.3.3 Current Population Uncertainties and Unknowns

The following is a list of uncertainties for the FL Keys mole skink populations:

- Occurrence of skinks in northern extent of historical range (Upper Keys). Current survey efforts are primarily concentrated in areas of the Lower Keys (mainly Refuge and state property) and these recent documented findings coincide-well with the historical documented sightings (Figure 2-2). It is believed that skinks currently exist in areas of the Upper Keys where they were historically documented. That is, current searches would be expected to find skinks in those areas with known historical records. However, recent surveys in the Upper Keys in areas with historic records have failed to observe skinks.

- Population abundance and minimum viable populations; population trends (birth rate); sex ratio (may be 1:1); fecundity; nesting success; nest success (number of eggs which hatch out of total laid); minimum viable population; adult survival rates; carrying capacity.
- Level of connectivity between Keys; the relationship between distance and immigration. Preliminary genetic evidence suggests more or less distinct, minimally- to non-interbreeding populations despite a high confidence that some level of stochastic dispersal that takes place from rafting.
- Home range is unknown. Individual dispersal occurs but is considered limited. Distances, timing and patterns of movement are uncertain. Males are expected to have a slightly higher dispersal range than females to search for mates during the breeding season. Female dispersal distances are likely lower than those of males' as they a) need to have sandy, dry soil available to them for nesting and b) remain with the nest.
- Juvenile dispersal is believed to occur for the purpose of establishing their own home ranges away from those of adults but movement distances of juveniles are unknown. There is a lack of information on resource sharing or if any level of overlapping ranges take place on the landscape.
- Quantity or quality of cover needed to maintain optimum temperature range and other microhabitat conditions are undefined.
- Quantity or metric for insects (food source) needed in the landscape is undefined.

3.3.4 Subspecies Needs

The subspecies' needs are similar to those that are identified at a population level: available suitable habitat, soils, ground cover, and food source. As well, at the subspecies level, there needs to be multiple healthy populations or a single abundant population occurring across the subspecies' range. There may be a) distinct, minimally- to non-interbreeding populations on each Key or b) some level of dispersal from rafting between some Keys providing at least a small level of connectivity between individuals of populations. Preliminary genetic sampling has identified at least four discrete (non-interbreeding) populations as described above but sampling on other Keys between or adjacent to these four Keys has not been completed and may show some mixing or variation of genetics. The minimum number of viable (resilient) populations necessary to sustain the subspecies is unknown. As an island subspecies, the relatively small, patchily distributed islands can each support only a small numbers of individuals (or separate populations). The distribution of suitable habitat and soils across the subspecies' range are necessary to support skink populations. The level of redundancy (distribution) operating within a subspecies is determined by the resiliency (abundance and health) of its populations.

CHAPTER 4 - CURRENT CONDITION AND FACTORS AFFECTING INDIVIDUALS AND THE SUBSPECIES

After identifying the most influential individual, population, and subspecies needs for the FL Keys mole skink, the current condition of the subspecies is evaluated. To determine the FL Keys mole skink current condition, the existing stressors have first been identified. Each stressor is considered in terms of the scale, intensity, and duration and the impacts it is having on the subspecies and habitat across its life history stages. Some stressors may be affecting the subspecies at all life stages or all individuals or populations across the subspecies' range while others may be specifically affecting a single resilience factor, such as the amount of suitable habitat, or a specific life stage. Some stressors, while present and acting on individuals of the subspecies, may not rise to the level of affecting the subspecies or even population(s). Factors influencing current condition included both negative stressors as well as beneficial conservation actions. Consideration and analysis were also given to the cumulative effects of these factors on the viability. The overall current condition is expressed in terms of population resilience, and subspecies redundancy and representation.

4.1 Methods

The most influential population resiliency factors were identified earlier under Section 3.3 Needs of the FL Keys Mole Skink. Stressors and their cause and effect upon these factors and the subspecies as a whole were primarily identified through 1) Technical Team discussion (December 2016), 2) FWC FL Keys mole skink Biological Status Review Report, 2011, 3) published literature, and 4) unpublished reports.

The primary stressors (in order from greatest to least current effect on the subspecies) identified for the FL Keys mole skink include:

- Climate change Sea Level Rise;
- Climate driven shifts in seasonal timing and amounts of precipitation and rainfall;
- Loss of habitat (development, conversion);
- Displacement or disturbance from human activities (tourism, beach cleaning);
- Change in habitat characteristics from invasive species (vegetative);
- Direct impact – displacement or removal by predators (primarily fire ants and feral cats);
- Hurricanes; stochastic events (high tidal inundation from storm surge; oil spills);
- Pesticides (primarily mosquito prevention spraying);
- Disturbance/destruction of habitat from off-road recreation vehicles (ORVs); dumping;
- Collection.

The identification of stressors and assessment of the current effect level of each stressor on the FL Keys mole skink was accomplished through a specific Technical Team Workshop on life history and current conditions of the Florida Keys and Cedar Key mole skinks, and through continued discussions with Technical Team Working Group members. The individual expertise of Technical Team Working Group members included herpetology, ecosystems of the Florida Keys, reptilian genetics, south Florida meteorology and climate change, and ecosystem mapping and contributed to identifying and addressing the current effects of these stressors on the FL Keys mole skink. An influence diagram was developed to illustrate the stressors and their influence on habitat and demography (Figure 4-1). An exposure table was also produced to further examine the exposure of each stressor (or activity) on the skinks biology and habitat and the consequences (or effect) upon the skinks (Appendix C).

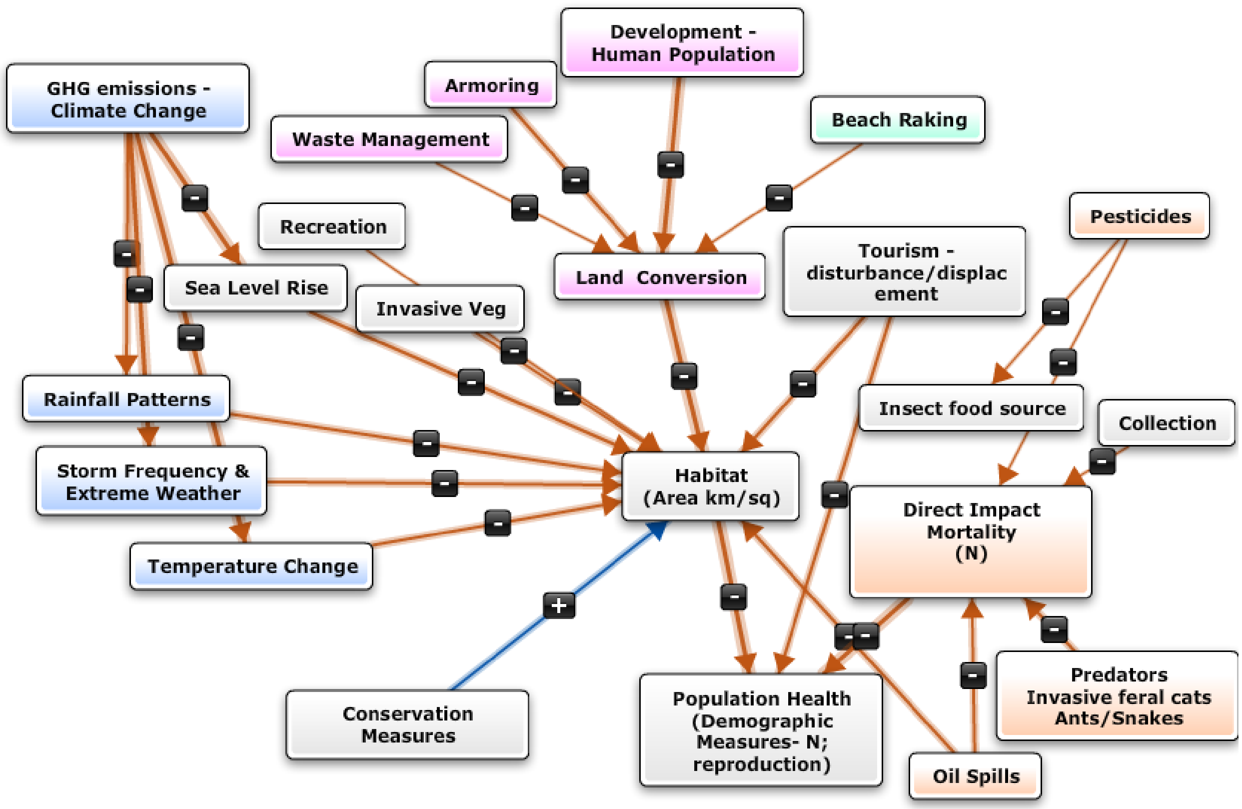


Figure 4-1. Influence diagram: factors influencing FL Keys mole skink habitat and demographics.

4.2. Factors Determining Viability

Additional detailed descriptions of some of the stressors can also be found in FWC 2011(p. 5) and FWC 2013 (pp. 3-5).

4.2.1 Climate Change

The predominant stressors currently affecting the FL Keys mole skink and its habitat are the rapid and intense shifts in climate occurring as a result of increasing greenhouse gas emissions (GHG). The persistence of the entire FL Keys archipelago is being challenged by increases in sea levels and shifts in seasonal climate patterns. The main stressors affecting the FL Keys mole skink and its habitat are increased sea level rise, more numerous King high tides (the very highest tides), increased storm surges, and shifts in seasonal patterns of rainfall and temperature.

The following scientific and ecological information on climate change includes summarized work by the National Climate Team and staff of the Service from the 2014 publication entitled *Climate Change Impacts in the United States: The Third National Climate Assessment* (NCA) (Carter et al. 2014, entire). This team also summarized the 2013 publication from the International Panel of Climate Change (IPCC) entitled *Highlights of the IPCC 5th Assessment Report: The Physical Science Basis of Climate Change (WGI); Summary for Policymakers* (IPCC, 2013, entire). This information is being further condensed with a primary focus on Florida (USFWS 2017, entire).

Sea Level Rise

The FL Keys mole skink inhabits and utilizes the transitional zone/beach berm (50 to 80 cm [20 to 31 in] above sea level) and the coastal hammock habitat during all of its life stages. It relies on these coastal habitats for food, nesting, and shelter, and this reliance makes the subspecies especially vulnerable to current and predicted sea level rise across its entire range. The Keys are a low-lying set of islands with an average elevation of less than one meter (3.2 ft.) (USGS SOFIA 2017; FDEP 2012a, p. 12). The area is highly susceptible to flooding, and land further upland is at risk of inundation and saltwater intrusion. Sea-level rise has been attributed to the conversion and loss of pine forest habitat in the FL Keys to more halophilic (salt-loving) vegetation (Ross et al. 1994, pp. 152-154). These effects – higher tidal surges, coastal and inland flooding, and saltwater intrusion- of increasing sea levels are currently being experienced in the south Florida and the FL Keys (Carter et.al 2014, pp. 398-400, 403; Wadlow 2016).

Since 1880, global sea level has increased by 0.20 to 0.23 m (8 to 9 in.), and the rate of increase over the past twenty years has doubled (USFWS 2017, p. 5). An average 0.08 m (3 in) increase in overall global SLR has occurred between 1992 and 2015 (National Aeronautics and Space Administration Jet Propulsion Laboratory [NASA] 2015, p. 2). This rise is equivalent to the Florida coastline subsiding at a rate of 0.04 inches a year (USFWS 2017, p. 6). The long-term trend in SLR at the National Oceanic and Atmospheric Association (NOAA) Key West Station shows a 0.0024 m (0.09 in) increase of the mean high water line (MHWL) per year from 1913 to 2015 (Figure 4-2). The NOAA Vaca Key Station (City of Marathon) shows a 0.0035 m (0.14 in) per year SLR between 1971 (start of data collection) to 2015 (NOAA 2017a) (Figure 4-2). Mean high water line is defined as, "The line on a chart or map which represents the intersection of the land with the water surface at the elevation of mean high water. (NOAA National Ocean Service [NOS]) 2017).

While the SLR rate for Florida has been equivalent to that experienced globally, recent analysis is now indicating an accelerated rate for the eastern United States above that of the global rate (NOAA 2017 b, p. 25; Carter et al. 2014, pp. 401-403; Park and Sweet 2015, entire). The global trend is currently on the higher-end trajectory of the scenarios, projecting a SLR of 2.5 -3.0 m by 2100. NOAA (2017b, p. 21) is recommending the use of the higher end estimates for future projections. The accelerated sea level rise in south Florida is being attributed to shifts in the Florida Current due to a) added ocean mass brought on by the melting Antarctic and Greenland ice packs, and b) thermal expansion from the warming ocean (Park and Sweet 2015, entire; Rahmstorf et al 2015, entire; NOAA 2017b, p14; Deconto and Pollard, 2016, p. 596). For this reason, it is now recommended to add approximately 15% to the earlier global mean SLR projections for the IPCC (2013, entire; Appendix D) when using projections for southeast Florida (including the FL Keys) if the projections used do not yet model the accelerated rate (Southeast FL Regional Climate Change Compact [Compact] 2012, p. 35; Park and Sweet, 2015, entire).

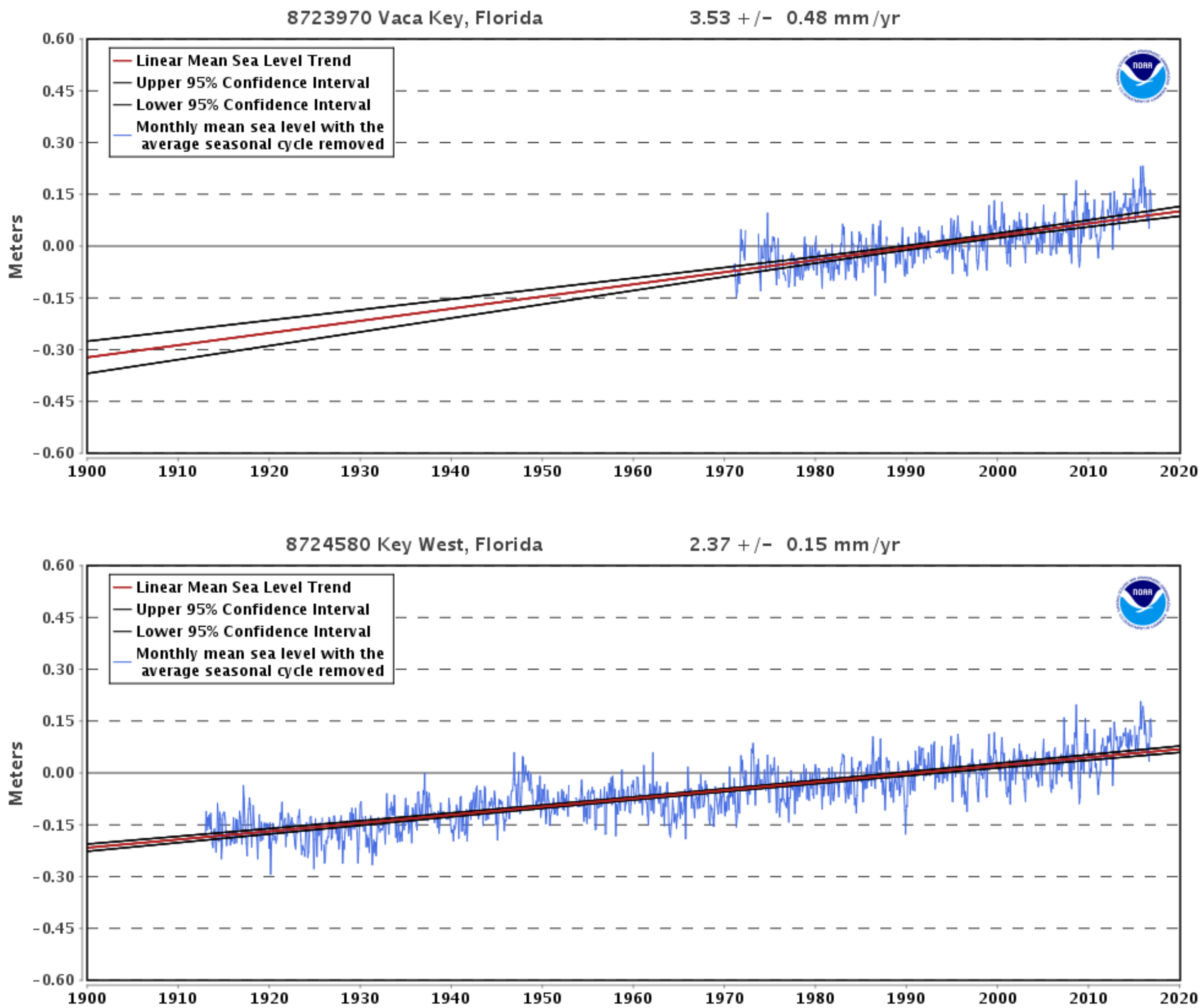


Figure 4-2. Key Vaca (1970 to 2015) and Key West (1913 to 2015) NOAA tidal gauges (NOAA 2017a).

Temperature and Precipitation

In the United States, the average temperatures have increased by 0.77 to 1.1 degrees C (1.3 to 1.9 degrees F) since record keeping began in 1895 (USFWS 2017, p.2). The decade from 2000 to 2009 is documented as the warmest on record (since record keeping began in 1895) (USFWS 2017, p. 2). The average temperatures in south Florida have increased 0.83 degrees C (1.5 degrees F) or more since 1991 (USFWS 2017, page 2). Because of the current condition of human-induced emissions (that is, the pattern of continued release of GHGs added to those already occurring in the atmosphere), increases in surface air temperature continue to rise. Even if there was an immediate and aggressive reduction to all GHG emissions caused by humans, there would still be expected continued increases in surface air temperature due to the lag in response to GHGs by the Earth's system (IPCC 2013; pp. 19-20).

The FL Keys mole skink is specialized for existing within this stable and relatively narrow thermal environment of the tropics and lacks the capacity to adjust or regulate to changes in temperature outside of this thermal range in which it occurs (Gallagher et al 2015, p. 62). This limiting coping ability to adjust to thermal stress outside of its temperature range increases the subspecies susceptibility to the local and regional increases in temperature occurring with global warming (Gallagher et al. 2015, pp.61-63). As mentioned in Section 2.2 Description, the optimum temperature range for the mole skink species (*Plestiodon egregius*), is from 26 to 34 degrees Celsius(C) (78.8 to 93.2 degrees Fahrenheit [F]) with a mean of 29.5 C (85.1 F) (Mount 1963 p. 363). Any continuously higher average number of hot days out of the skink's optimum range or a permanent shift in average air temperature out of this range, even by 0.28 degrees C (0.5 degrees F), can stress them physiologically or shift reproductive cues (Adolph and Porter 1993, p.276). Increases in sand temperature (their surrounding habitat) would likely alter their movements and time spent under cover within the sands (Adolph and Porter 1993, p. 275- 278, 290). It is uncertain about the level of specialization of the FL Keys mole skink in its ability to accommodate to temperatures outside of its thermal range. Large changes outside of the skink's optimal temperature range can lead to decreased fitness and mortality of individuals. The impacts from this stressor are based on the level and duration of thermal changes and the capacity for individual skinks to physiological or behaviorally accommodate to these changes.

Temperature-dependent sex determination (TSD) has been documented for most reptilian species but not all (a few reptiles have shown to not exhibit TSD or an environmentally determined sex ratio) (Bull 1980 p.7). Recent work has indicated that both genetic and temperature-dependent sex-determination mechanisms co-occur and function interrelatedly in the lizard species *Pogona vitticeps* (Holleley et al. 2015, entire). The plasticity of this "dual system" implies a potential for this species to rapidly shift from what is a temperature- sensitive genetic mechanism (GSD) to a TSD mechanism under high incubation temperatures (Holleley et al 2015, p. 79-80). This transition or temperature override was found to evolve rapidly in response to high temperatures and resulted in the development of more females and the loss of mixed chromosomal offspring (Holleley 2015, pp. 80-81). How prevalent this rapid transition-response is in other reptilian species is uncertain. While no direct study of TSD or the transitioning of sex-determinant mechanisms in the FL Keys mole skink exists, TSD has been identified in skink species in the same Family (Scicinidae) (Robert and Thompson 2009, entire; Ji et al. 2006, entire). Sarre et al. (2004, p. 640,642-643) proposed that the genetic and environmental sex determination mechanisms commonly co-occur and function as a continuum in reptile species. How the fluidity between these two mechanisms ultimately affects the fitness and genetic representation of a species is still unclear, but this mechanism is expected to be influenced by the increasing temperatures from climate change (Holleley et al 2015, p. 81; Bull 2015, p.44).

Increased temperature out of an optimal range and extreme high or low moisture contents of sandy soils (a nesting substrate) will physically influence the environment of the FL Key mole skink nests in this substrate as well. It is likely that a shift to average higher sand temperatures would modify incubation periods, embryo temperatures, egg survival, hatching times, and possibly sex ratios of the FL Keys mole skink (Packard et al. 1977, pp.75-82; Bull 1980, pp. 16-17; Warner and Shine 2008, pp.566-567; Van Damme et al. 1992, pp.224, 226).

Precipitation patterns are also changing. The NCA reports that average precipitation has increased by five to ten percent since 1900 in south Florida (Walsh et al. 2014, pp 32-35). Shifts in seasonal rainfall events as well as increases in average precipitation are currently being documented (USFWS 2017, pp. 405). The south Florida dry season (November through April) has become wetter, and the rainy season (May through October) has become drier. Current projections show this trend to continue and are discussed in the Future Scenarios chapter.

Heavy downpours in south Florida are currently increasing and have especially increased over the last 30 to 50 years. Since the 1970s, there is a twenty-seven percent increase in the frequency and intensity of heavy downpours (USFWS 2017, p. 4). Increased inland flooding is predicted during heavy rain events in low-lying areas. With worsening storms, storm surges along coastlines become stronger and push inland further. Inundation of soils from storm surges can cause saltwater intrusion, compaction of sand, and the inability or difficulty for FL Keys mole skinks to dig nests and burrow. More powerful storm surges exacerbate effects of the increased sea level along shorelines. Increased incidences of inland flooding and of low-lying areas are being documented regionally and locally (Staletovich 2016; Sheridan 2015).

4.2.2 Land Development and Conversion

The habitat for the FL Keys mole skink occurs as fragmented parcels across the islands of the FL Keys. The current amount of land mass, suitable habitat, and suitable soils for the FL Keys mole skink was identified earlier in the Habitat Section. The main islands of the Keys (including Key West, Big Pine Key, and Marathon), are highly impacted by human development, but there are also areas of native habitat within the Refuge, Dry Tortugas National Park, State Parks (Long Key, Bahia Honda, Curry Hammock), and other undeveloped parcels that occur intermittently across the subspecies range. These areas provide suitable habitat and soils for the FL Keys mole skink (See Conservation Actions and Table 2-2 for a more comprehensive list). So, while it is a small and highly impacted island-system, parcels of suitable habitat and soils remain which support the current distribution of this subspecies.

There is high uncertainty in the current and potential occupancy of the backwater islands by the FL Keys mole skink. Current surveys on two relatively remote Keys, Sawyer and Content, Key have recorded a few skinks (Figure 2-2). Two skinks were documented on Sawyer Key in 2015, and one in 2016. Three skinks were documented on the same day in 2017 on Content Key. For this reason, these small islands also need to be considered as potential habitat under current condition.

Development

In 2010, Monroe County had 3.81 people per 0.4 ha (1 acre) and a population of 73,044 people (Carr and Zwick 2016, p. 29, 27). Carr and Zwick (2016, p. 27) estimate a “medium” growth in population with a six percent population increase in Monroe County by 2070. There are projections that all vacant land in the FL Keys could be consumed by development by 2060 (Zwick and Carr 2006, p.15).

The FL Keys mole skink inhabits the same coastal beach berm and hammock habitat that is desirable for residential and commercial manmade development. Individual skinks do show some tolerance of habitat alteration and are occasionally documented in cemeteries, vacant lots, backyards and golf courses (Emerick pers. comm. 2017c; FNAI 2011; Mays and Enge 2016, p. 10). However, development and conversion of beach and coastal hammock habitat are capable of impacting all of the skink life stages. In addition to direct impacts from loss of soils for nesting and movement, ground cover and availability of the insect food sources found in the ground cover can be reduced. Loss of habitat reduces shelter and shade for adults. Indirectly, connectivity is further decreased hindering population dynamics in finding mates and dispersal to new locations by juveniles.

In areas with networks of roads such as Big Pine Key, Key West, and Boca Chica, and along the Overseas Highway, direct mortality from vehicle strikes may be taking young and adult skink individuals. This is expected to be a minor impact to subspecies populations based on the relatively limited home ranges of skinks within their habitat. Roads and manmade structures can fragment habitat and populations leading to a reduction in population health and genetic diversity (Jochimsen et al. 2004, p. 40). An additional conversion and degradation of habitat that is associated with development and increased human populations is the use of land for refuse. Waste management is a huge challenge on the limited amount of land.

As beach front and coastal systems in the Keys are developed, displacement to higher elevations for the FL Keys mole skink is an extremely limited option given the current level of build-out and conversion of these low-lying islands. As mentioned, the ease and likelihood of skinks to colonize new habitat on other Keys is limited given the island geography and their limited dispersal mechanisms**.**

4.2.3 Disturbance

The FL Keys are heavily visited by tourists and seasonal visitors. The increased density of people places pressure on the habitat. The Keys are well-known for their outdoor recreational activities, particularly waterfront and beachfront activities which directly overlap with the habitats used by the skinks. All life stages of the FL mole skink are being impacted by these activities and the infrastructure needed to support the tourism industry.

Approximately 2 million non-Monroe County residents visited the FL Keys from December 2007 to November 2008 (Leeworthy 2010, p. 2). The Bahia Honda State Park, Dry Tortugas National Park, Long Key State Park, Curry Hammock State Park, and several other private sites all allow camping (Florida Rambler 2017, entire). Hiking, beach combing, and other activities (sunbathing, picnics) along the beachfront and in the coastal hammock can cause direct disturbances to the skink's behavior and habitat. Beach cleaning directly removes wrack and vegetative material that act as cover and food sources for the skink. The behaviors (feeding, movement and nesting) of individual skinks are very likely being disturbed by beach and upland activities. These disturbances could certainly rise to the population level depending on their intensity and duration.

There are very clear increases in both winter (generally considered to be October to April) inhabitants and tourists that place pressure on the Keys' resources during these months; however, the Keys receive visitors, tourists, and recreationalists year-round. A few of the locations that experience high impacts from visitors include Islamorada, Big Pine, Bahia Honda and Key West. Increased road traffic is a direct consequence of visitors and tourists as is the need for parking. Off-road parking sites, gravel lots and boat trailer parking can disturb the dry soils and areas used by skinks. Smaller off-road vehicles, such as ORVs and golf carts are also sometimes used in communities to get around locally. These small vehicles use non-paved areas and off-road areas that can displace, disturb, or cause direct mortality of individual skinks.

An additional source of potential disturbance of skinks is via specific land management activities. State rule 68A-27.007(2) (c), F.A.C. authorizes land management activities such as; prescribed fire and herbicide application, without an incidental take permit (FWC 2016a p. 5). These activities may be beneficial to the long-term quality of the natural habitats for the FL Keys mole skink but result in local disturbance and direct mortality of individual skinks.

4.2.4 Stochastic events

Demographic stochasticity refers to random variability in survival or reproduction among individuals within a population (Shaffer 1981, p. 131). Demographic stochasticity can have a significant impact on population health, particularly for populations that are small, have low fecundity, and are short-lived. In small populations, reduced reproduction or temporary die-offs of a certain age-class will have a significant effect on the whole population. Although such impacts may have less of a consequence to a large population or to a (sub) species with many populations (high redundancy), this randomly occurring variation in individuals becomes an important issue for small populations.

Environmental stochasticity is the variation in birth and death rates from one season to the next in response to weather, disease, competition, predation, or other factors external to the population (Shaffer 1981, p. 131). For example, drought or predation, in combination with a low population year, could result in extirpation. The origin of the environmental stochastic event can be natural or human-caused. Extreme events are expected to increase in strength and frequency with accelerated climate change.

Storm Events

There has been a substantial increase in most measures of Atlantic hurricane activity since the early 1980s, the period during which high-quality satellite data are available. These include measures of intensity, frequency, and duration as well as the number of strongest (Category 4 and 5) storms (Walsh et.al. 2014, p. 20). Strong rainstorms, tropical storms, and hurricanes are all natural parts of a tropical ecosystem. However, even though they are common occurrences, they are not harmless. The health of the FL Keys mole skink subspecies becomes vulnerable when the quantity and quality of their resources (food, cover, nesting beach) are compromised. This can particularly happen in the case of storm surges and with an increase in the number of incidences (being impacted repeatedly without time to recover).

Hurricane activity has been above normal since the Atlantic Multi-Decadal Oscillation (AMO) (the natural variability of the sea surface temperature in the Atlantic Ocean) went into its warm phase around 1992. Currently, while the incidence of tropical storms in southeast Florida (including the Keys) is above normal, this frequency is expected to decrease with climate change but the intensity of the storms is expected to increase by approximately 10 percent (See Future Conditions section) (USFWS 2017, p. 7). This increased intensity results in larger tidal storm surge and greater destruction than historically documented. Ecosystem resiliency is reduced when impacts by extreme events such as floods or storms occur (USFWS 2017, p. 7). Saltwater intrusion from storm surge and flood result in displacement landward to less suitable habitat and the loss of individual mole skinks. The unconsolidated dry soils become wet and compacted. The recent increases in storm strength are linked, in part, to higher sea surface temperatures occurring in the equatorial regions of the Atlantic Ocean where hurricanes form and move. Numerous factors have been shown to influence these local sea surface temperatures, including natural variability of the AMO, human-induced emissions of heat-trapping gases, and particulate pollution.

Sufficient long-term monitoring of the FL Keys mole skink subspecies and information on strong storm impacts to this subspecies are lacking. However, information does exist on the impacts to habitat from hurricanes and other strong storms that have occurred in the region that can provide some insight of the potential damage and loss to the FL Keys mole skink from such storms. These events very likely disturb and reduce the quantity and quality of their resources (food, cover, nesting beach) and may do so significantly depending upon the severity and proximity of the storm center. This is particularly the case of storm surges which bring in nutrient-rich sediment that exacerbate soil accretion, deposit salt, and damage vegetation (Dingler al. 1995, p. 296; Jackson et al. 1995, p. 321, Enge et al. 2017). If in cases when storms are not too destructive, vegetative material can be deposited in localized areas high on the beach and ultimately provide habitat and increased insect food sources for the skinks.

Saltwater surges and short-term flooding of upland habitats from strong storms and hurricanes in the Keys likely have and will continue to kill mole skinks (FWC 2013, p. 4). In 2005, Hurricane Wilma (Category 3) passed just north of the FL Keys causing maximum storm tides 1.5 to 1.8 m (5 to 6 ft.) above mean sea level in Key West and flooding approximately 60 percent of the city. On Boca Chica and Big Pine Keys, Hurricane Wilma caused a storm surge of 1.5 to 2.4 m (5 to 8 ft.) (Kasper 2007). According to Lopez et al. (2004, p. 284), a storm surge of 4 m (13 ft.) would result in the complete submersion of Big Pine Key, where a documented population of the FL Keys mole skink occurs.

The storm effects on a Key archipelago system were recently documented in North Key (of the Cedar Keys island complex in the north-east Gulf of Mexico) after hurricane Hermine came through in September 2016 (Figure 4-3). Alternations and wash-out to the beach and coastal hammock were widespread. Vegetation became buried and the ground cover was noticeably reduced (Figure 4-3). The beachfront of North Key lost most of the important habitat cover required for the Cedar Key mole skink. Similar impacts can be expected in the FL Keys. Ecosystem resiliency and suitable habitat used by the FL Keys mole skink is reduced with impacts by extreme events such as floods or storms. Saltwater storm surge and flood would likely result in displacement landward and the loss of individual mole skinks. These same events could trigger opportunities for skinks to become passively dispersed if carried on rafting debris. The severity and duration of these impacts to the skink vary based on the intensity and scale of the events.

Figure 4-3. North Key (Cedar Key subspecies habitat 2015 (Left); North Key (Dec. 2016) after Hurricane Hermine impacted the area in September 2016 (Right). (Kevin Enge, FWC)

The heavy inundation and even complete overwash of some Keys during hurricanes may provide some explanation for the lack of skinks being observed, even when the Key has recovered and again contains high quality suitable skink habitat. Ohio Key in the FL Keys is being regularly surveyed by Refuge staff and despite available high-quality suitable habitat and numerous searches, no FL Keys mole skinks have been located there. As mentioned, impacts from heavy rainstorms, tropical storms, and hurricanes are part of this tropical island system. Over time, this process may be a factor towards reducing the persistence of skink populations and thereby reducing the redundancy available in the subspecies. Storm events are likely a contributing factor to the low historic and current abundance observed for this subspecies. Individual skinks may colonize and occupy smaller Keys only temporarily until storm events impact that island. Eventual recolonization of impacted Keys by skinks is uncertain.

Oil spills

Every year, thousands of oil spills occur in the United States, but most involve the spilling of less than one barrel of oil (NOAA Office of Response and Restoration [ORR] 2017c). Since 1969, there are been at least forty-four oil spills greater than 10,000 barrels in U. S. waters including the largest to date, the 2010 Deepwater Horizon spill in the Gulf of Mexico (NOAA ORR 2017c). There have been 16 oil spills recorded in the Gulf of Mexico responsible for the spilling of at least 0.05 million gallons (NOAA 2017c). There have been eight spills in the Caribbean

Seas with at least 0.05 million gallons spilled (NOAA 2017c). Any large spill has the potential to reach the shore of the FL Keys.

Offshore oil tanker spills pose the same threat. Following the Deepwater Horizon spill, a study of contaminants in diamondback terrapins (*Malaclemys terrapin*) in Louisiana showed that turtles in areas with higher exposure to crude oil had higher levels of contaminants in their systems. Drabeck et al. (2014, pp. 132–133) found higher levels of toxic contaminants (2-ring aromatic hydrocarbon biphenyl, alkylated PAH dimethylnapthalene, and Biphenyl) in the reptiles' tissues sampled. These substances are most commonly associated with crude oil and gasoline (Drabeck et al., 2014, pp. 132–33). Depending on the location and severity of the incident, oil spills could affect all life stages of the FL Keys mole skink.

4.2.5 Predators

Native snakes have been documented as natural predators on mole skinks (Hamilton and Pollack 1958, p. 28, Mount 1963, p. 356). The red cornsnake is known to be abundant in the Keys and to frequently prey on lizards (Enge, K. pers. comm., 2017). There is no evidence of impacts to the FL Keys mole skink by this snake. This predator-prey process has probably remained unchanged over time and currently presents no significant threat at the population or subspecies level for the FL Keys mole skink.

The Monroe County government (2012) estimates that thousands of feral cats roam free in the FL Keys (particularly Key West). Feral cats are instinctively natural predators and have been documented killing a variety of lizard species including: eastern fence lizard (*Sceloporus undulates*), five-lined skinks (*Plestiodon fasciatus*), broad-headed skinks (*Plestiodon laticeps),* and ground skinks (*Scincella lateralis*) (Mitchell and Beck 1992, p. 200). Feral and all free-roaming cats present a significant threat to all life stages of the FL Keys mole skink where they are present in skink habitat (Calver et al. 2011, entire). Direct evidence is lacking on the current level of impacts that feral and free roaming cats have on the FL Keys mole skink. Given the limited dispersal and possibly clumped distribution, cat predation could negatively reduce or eliminate a skink population (FWC 2013, p.5).

4.2.6 Invasive species

The semi-fossorial nature and small size of the FL Keys mole skink makes all life stages, particularly the eggs, susceptible to the red imported fire ant (*Solenopsis invicta*). Fire ants have been documented killing numerous reptile species eggs and hatchings. Fire ants may also indirectly impact adults by affecting survival and weight gain, behavioral changes, changes in foraging patterns and habitat use, and reduced food availability (Allen et al. 2004, p. 90-91). A study conducted in the Lower Keys, showed that transects closest to roads and which had the largest amount of development within a 150 m (492 ft.) radius of a road had the highest probability of the presence of fire ants (Forys et al. 2002, p. 31). Fire ants could also be a food source for this insect-eating generalist, but this has not been documented and is not expected to be a preferred food source given the stinging capability of the ants.

The brown anole (*Anoles sagrei*) and tropical house gecko (*Hemidactylus mabouria*) are non-native lizards that may be potential predators to the FL Keys mole skink hatchlings. The nonnative ashy geckos (*Sphaerodactylus elegans*) and the (*S. notatus notatus)* forage in leaf litter and may complete with the FL Keys mole skink for food resources (Enge, K., pers. comm. 2017). The level of predation or resource competition that the FL Keys mole skink subspecies is experiencing from these invasive lizard species is unknown but not believed to be stressors to the population or subspecies level.

As mentioned, native snakes are expected to occasionally prey on mole skinks but the impact of invasive species preying on FL Keys mole skink is unknown (Hamilton and Pollack 1958, p. 28, Mount 1963, p. 356). Exotic boa constrictor, Burmese python, and anaconda snakes are known to occur in south FL, generally from the illegal release of these animals when held as pets. These are large-sized snakes which target large prey for their survival. The FL Keys mole skink is not considered a preferred prey by these snake species. Predation of the FL Keys mole skink by these species is unlikely and has never been documented.

Nonnative plants have significantly impacted native habitats in south FL (Bradley and Gann 1999, pp. 15, 72). Nonnative, invasive plants compete with native plants for space, light, water, and nutrients, and make habitat conditions unsuitable for mole skinks by changing or reducing leaf ground cover, increasing root masses in friable soils as well as loss of shade, and protective cover. If nonnative vegetation cover is not as dense as native vegetation, changes in soil temperature could result and negatively impact the FL Keys mole skink.

4.2.7 Collection

The collection of FL Keys mole skinks is considered low and an insignificant stressor on the subspecies. A four-year study on the commercial harvest of amphibians and reptiles in Florida documented the capture and sale of four FL Keys mole skinks (two in 1990-1991 and two in 1993-1994) (Enge 2005, p. 211). Small skinks such as the FL Keys mole skink are more often sold as snake food or captured incidentally during hunts for snakes (Enge 2005, pp. 198-211). Current internet searches for the sale of any *Plestiodon* skinks did not find any skinks for sale (Amazon 2017; Ebay 2017). Online searches by FWS staff biologists found two records of previously independent searches from 2013 and 2008 of consumers looking to purchase mole skinks (Fauna Classifieds 2017; Yahoo answers 2017). No responses to these inquiries were found. The collection of mole skinks would primarily target the adult and juvenile life stage. Adult female skinks are expected to be particularly vulnerable when attending a nest.

4.2.8 Pesticides

Current broad use of pesticides for mosquito control occurs in the Keys. The FL Keys Mosquito Control District includes centers in Key Largo, Marathon (Key Vaca), and Key West. Methods used include truck spraying, aerial adulticide and aerial liquid larvicide spray missions, and local community manual spraying (FL Keys Mosquito Control District 2017). The most common pesticides used for mosquito control in the Keys include Vectobac GS and WDG, Dibrom, Permanone 30-30 and Fyfanon ULV. There are specific "No-Spraying" zones throughout the Keys that primarily consist of Refuge, Sanctuary, and state park properties as well as other tracts of undeveloped lands. Spray treatments appear to be concentrated in the larger populated cities and communities. This targeted method of mosquito control treatment affords some reduced exposure to the FL Keys mole skink. The region-wide range of the mosquito control program could possibly be having an unidentified direct impact to the FL Keys mole skink. Indirect effects could be occurring via impacts to their insect food sources, ground cover, and through soil absorption. Because of its widespread nature, the impact of mosquito spraying would be at the population and subspecies level. At this time, no evidence exists to indicate that this activity is a negative stressor on the FL Keys mole skink at the population or subspecies levels.

4.2.9 Disease

There is no sign or documentation of parasites or disease acting as stressors on the subspecies.

4.3 Cumulative Cause and Effect

Rarely do stressors act alone in the environment and therefore their cumulative effects to the subspecies and habitat also need to be considered. Even minor stressors that impact just a few individuals in a population need to be considered for their additive effects. For example, the effects from invasive species, pesticide impacts, and collections may each be a low risk to individual skinks but cumulatively can become a moderate or severe stressor to the population abundance. Stressors were considered cumulatively for their effects on the FL Keys mole skink and were currently found to not impose negative effects at the population or subspecies level.

Various stressors can originate from a similar cause but produce a set of interdependent effects on the FL Keys mole skink. Global greenhouse gas (GHG) emissions increase the rate and severity of climactic changes which act in combination as stressors on the subspecies. These include a) SLR, b) seasonal shifts in timing and amounts of precipitation, c) shifts in temperature patterns, d) and increased storm intensities which affect the subspecies. Increased mean (average) high water line resulting from SLR reduces available suitable habitat for the FL Keys mole skink. Because the average high water line is now higher than historic levels, areas not typically flooded are now flooded on a more regular basis.

Increased incidence and intensity of storm surge is another stressor produced by the occurrence of more severe storms. This surge exacerbates the level of flooding and inundation. Increased rainfall, along with the stressors of SLR and higher than average storm surges, further reduces habitat quality through soil compaction and increased durations of wet soils. This negatively affects nesting ability, skink movement, and availability of insect food sources that rely on dry ground cover. Each of these stressors alone affects the overall viability of the subspecies and its habitat but combined produce synergistic or worsening impacts on the subspecies.

4.4 Conservation Actions

The FL Keys mole skink subspecies was state-listed as threatened by Florida in 1974 but was changed to a State of FL species of concern in 1978. In 2010, after a subspecies status review by the FWC, the FL Keys mole skink was again found warranted for listing as a state threatened species. The FWC justified the state threatened listing for the FL Keys mole skink based on the subspecies' very restricted area of occupancy (estimated at 20.3 km^2 [7.8 mi^2]) and the current threat of loss or degradation of habitat (FWC 2011, p. 10).

A FL Keys mole skink State Action Plan (SAP) was developed in 2013 (FWC 2013). The goal of the plan is to improve the conservation status of the FL Keys mole skink to the point in which the subspecies is secure within its historical range (FWC 2013, pp. 8-19). Fifteen action items in eight categories were identified for accomplishing this goal.

The categories include:

1) Habitat conservation and management;
2) Population management,
3) Monitoring and research,
4) Rule and permitting intent,
5) Law enforcement,
6) Incentives and influencing,
7) Education and outreach, and
8) Coordination with other entities (FWC 2013 pp. 17-18).

The SAP also classifies the FL Keys mole skink as a State of FL cryptic species. The term "cryptic species" is defined by the State of FL as "a species that may not be easily observed, tracked, or surveyed due to camouflage or behavior rather than rarity" (FWC 2016b, entire). The FWC's policy on cryptic species states that any permitting of cryptic species will focus on cooperation and collection information instead of regulation. Information on distribution and habitat use of FL Keys mole skinks that provide scientific benefit for species conservation may be justification for permitting a restricted activity (FWC 2016b, p. 34).

The state threatened listing of the FL Keys mole skink prohibits the intentional take, and some forms of incidental take, of the subspecies. Florida state rule 68A-27.001, F.A.C., defines incidental take as, "take that is incidental to, and not the purpose of, carrying out an otherwise lawful activity" (FWC 2016b, p.15). Take of a species includes harass, harm, pursue, hunt, shoot, wound, and kill, trap, capture, or collect. The definition of harm may include such acts that significantly modify habitat to results in killing or injuring the species by impairing the animal's ability to breed, feed, or shelter (FWC 2016b, p. 15). Incidental take may require a permit from the FWC. A permit will only be issued if the activity will not have a negative impact on the survival potential of the species. The FWC lists several avoidance measures including: avoiding impacts to coastal strand, coastal dune, pine rockland, and tropical hardwood hammock habitats within the range of the FL Keys mole skink (FWC 2016a, p. 5). Specifically, these measures recommend a) avoiding the removal of microhabitat features and b) the prevention of activities that cause soil compaction. State rule 68A-27.007(2) (c), F.A.C. authorizes land management actives such as prescribed fire and herbicide application without an incidental take permit (FWC 2016a p. 5). As mentioned, some of these land management activities may be beneficial to the long-term quality of the natural habitats for the FL Keys mole skink but can result in local disturbance or direct mortality of individual skinks.

The FL Coastal Management Plan designates the FL Keys as an Area of Critical Concern due to the Keys' environmental sensitivity and the development pressures currently underway on the islands (FDEP 2014, p. 25). Through the FL Forever program (and the previous State of FL Conservation and Recreation Lands and Preservation 2000 Programs), the Monroe County Land Authority and the State of FL has purchased 4249.6 ha (10,501 ac) of FL Keys land for the protection of natural resources (Florida Department of Economic Opportunity 2015 p. 12).

The Monroe County Land Authority was created in 1986 to acquire property for conservation, recreation, and affordable housing. The 2017 fiscal budget appropriates $6,749,360 of funds for land purchase in the FL Keys (Monroe County Comprehensive Plan [MCCP] Land Authority 2016, p. 2). While these lands were not acquired specifically for the FL Keys mole skink, conservation of imperiled species is an objective. The FL Keys mole skink will indirectly benefit through these land conservation and management actions (Florida Department of Economic Opportunity 2015, p. 12).

The MCCP addresses the protection of native habitat and land development in the FL Keys (Keith and Schnars 2016, p. 31). The MCCP limits the density and size of residential and what the author's define as "non-residential" development. Monroe County Planning and Environmental Resources Department also uses a minimum open space ratio that varies by land use category (Keith and Schnars 2016, entire). These actions aid in minimizing loss of natural habitat (Keith and Schnars 2016, p. 97). It should be noted that while limiting density can keep population numbers down and reduce pressure on a system, it can lead to urban sprawl.

Several local government plans provide conservation actions or can provide indirect conservation benefits to the FL Keys mole skink. The Village of Islamorada, the City of Marathon, and the City of Key West also have comprehensive plans that incorporate protecting native habitats and species (Village of Islamorada 2001, entire; City of Marathon 2005, entire; City of Key West, 2013, entire).

The USFWS Coastal Program is a conservation tool in the FL Keys. This program provides valuable technical and financial assistance to public and privately-owned coastal lands by supporting habitat conservation projects (USFWS 2012)

The NOAA Coastal Zone Management (CZM) Program addresses' the issues of climate change, ocean planning, and planning for energy facilities and development. The program was established by the CZM Act of 1972. This is a voluntary partnership between the federal government and the coastal states. This program funds coastal improvement projects in both aquatic and terrestrial habitats which can improve and restore skink habitat and soils (NOAA 2017d).

4.4.1 Conservation Lands

There are numerous federal, state, county, city, and private organizations that manage conservation lands throughout the FL Keys and provide conservation benefits and protections to the FL Keys mole skink. Some sites, particularly the county and city beach parks, do allow for heavy recreational use and manipulation of the natural beach habitat which can be disruptive to the subspecies. However, these areas also provide protection from heavy development and urbanization and allow for the persistence of sandy soil habitats. A comprehensive list of these lands is provided in Table 4-1. These areas provide all or some of the following conservation benefits to the FL Keys mole skink:

- Management of natural habitat including the maintenance and restoration of functioning beach berm and coastal hammock systems.
- "Leave no trace" practices and principles which are designed to reduce or eliminate impacts by humans visiting or using the lands.
- Prevention or minimization of the collection/removal of mole skinks.
- Prohibition or limited-use of activities aimed at preventing disruptions, impacts or losses to natural habitats and the species. These include such things as: no motorized vehicles, no ORVs or bicycles allowed or only allowed on some trails (limited to foot traffic only); human exclusion of sensitive environmental sites, reduction of noise and light pollution; No dumping, no searching for antiquities, no release of exotic species.
- Provide environmental education and interpretive services to the public on natural habitat and species: "Good stewardship" practices.
- Aquatic sanctuary and preserve lands provide buffers on coastal habitat by minimizing high impact coastal recreational use and development of these areas.
- "Conservation in perpetuity". Commitment of the conservation land owner to the long-term conservation and management of native habitat and species.

The collection of FL Keys mole skinks on any State, Federal, or public land is currently prohibited by state statue Rule 68A-27-.001(4), F.A.C. (FWC 2016b, p. 15). The Florida State Parks also have specific rules prohibiting the collection, destruction, or disturbance of all plants and animals within state park properties (FL State Parks 2017).

Also, the Department of Defense Naval Air Station Key West on Boca Chica Key has existing beach and upland habitat occurring around the airstrip that is undeveloped and while not designated as conservation lands, does currently provide suitable habitat (FWC 2004, p. 7). One of the genetically identified populations occurs on Boca Chica Key (discussed previously in Section 3.3.2 Population Structure).

Table 4-1. Federal, state, county, and private conservation lands in the FL Keys.

Conservation Land	**Location**	**Hectare (ha) (acres)(ac)**	**References**
Federal			USFWS 2009, p.11; USFWS 2006, p. 1; National Park Service (NPS) 2015, pp. v.1, 5.
National Key Deer Refuge	Big Pine Key and No Name Key, includes genetically identified FL Keys mole skink population	3,635 ha (8,983 ac)	
Crocodile Lake NWR	Upper Keys	2,448 ha (6,050 ac)	
Great White Heron NWR	Middle Keys; includes Sawyer Key with 2015-2016 documentation of three skinks.	2,550 ha (6,300 ac)	
Key West NWR	Key West	817 ha (2,019 ac)	
Everglades National Park	Backwater islands; Florida Bay, West of the Keys.	610,670 ha (1,509,000 ac)	
Dry Tortugas National Park	West of Key West; seven small islands and marine habitat. Historical skink documentation.	25,899 ha (approximately 64,000 ac)	
State			
FWC FL Keys Wildlife and Environment Area	Key Largo to Summerland Key	1,812 ha (4478 ac)	FWC 2013, p.3;
FDEP State Parks (SP): occur throughout the range of the FL Keys mole skink			FDEP 2003, p. 1; FDEP 2004a, p. 1; FDEP 2004b, p. 1; FDEP 2012a, p.1; FDEP 2012b, p.1; FDEP 2012c, p. 1; FDEP 2016a, p. 1; FDEP 2016 b, p. 1;
Dagny Johnson Key Largo Hammock Botanical State Park	Key Largo	993 ha (2,454 acres)	
John Pennekamp Coral Reef SP	Key Largo	25,722 ha (63,561 ac)	
Windley Key Fossil Reef Geological SP	Windley Key	15 ha (37 acres)	Snyder, P. pers. comm. 2017;
Indian Key Historic SP	Indian Key	45 ha (111 acres)	
Lignumvitae Key Botanical SP	Lignumvitae Key	4,377 ha (10,818 ac)	
Long Key SP	Long Key	398 ha (984 acres)	Institute for Regional

Curry Hammock SP	Little Crawl Key	450 (1,112 ac)	Conservation (IRC) 2017;
Bahia Honda SP	Bahia Honda Key	56 ha (138 ac)	
Fort Zachary Taylor Historic SP	Key West	450 ha (1,112 ac)	
Monroe County Parks			
Friendship, Sunset Point Park, Key Largo Community Park	Key Largo	NA	Monroe County Parks Beach 2017;
Settlers Park, Burr Beach Park, Harry Harris Park,	Tavernier	NA	City of Marathon, Florida 2017;
Veterans Memorial Park	Little Duck Key	NA	City of Key West Florida Major Parks and Facilities 2017
Blue Heron Leisure Club, Big Pine Park, and Palm Villa Park	Big Pine Key	NA	
Ramrod Park	Ramrod Key	NA	
Sugarloaf School	Sugarloaf Key	NA	
Bay Point Park	Saddlebunch	NA	
Big Coppitt Park and Wilhemina Harvey Park	Big Coppitt	NA	
Boca Chica Beach	Geiger Key	NA	
Bernstein Park	Stock Island	NA	
Higgs Beach and Key West Pines Park	Key West	NA	
City			
Sombrero Beach and Coco Plum Beach Parks	City of Marathon, Big Pine Key	NA	
Little Hamaca, Smathers Beach, Simonton St Beach, Rest Beach/C. B. Harvey, and Sonny McCoy Indigenous Parks	City of Key West, Key West	NA	
Private			
Torchwood Hammock Preserve	Little Torch Key	98 ha (243 ac)	

4.5 Current Resilience, Redundancy, and Representation

4.5.1 Population Resilience

As defined earlier, resiliency is the ability to withstand stochastic disturbances and is associated with population abundance, growth rate, and habitat quality (Shaffer and Stein 2000, pp. 308-310). The size of sites (with available suitable habitat) can also be a measure of resiliency. Generally, larger areas of suitable habitat support greater resilience than smaller areas. Resiliency is reflected by the quality of the factors resources mentioned above, as well as genetic diversity, population abundance, and demography.

Due to the semi-fossorial and cryptic nature of the FL Keys mole skink and limited research on all of the FL mole skink subspecies, there is limited understanding about the population structure and demographics of the FL Keys mole skink. Four genetically discrete populations have been identified from preliminary genetic research with very small sample sizes. Each of the four Keys sampled by geneticists has a unique genetic identification. Three of the Keys, Big Pine, Bahia Honda, and Boot Key also have historical records which suggest a level of resiliency for individuals (or a population) at these sites. Boca Chica has no historical observations documented (refer to Section 3.3.2 Population Structure). These four identified genetic populations do not constitute the entire subspecies population.

Little information exists on the abundance or growth rate of these populations. Therefore, a full picture of the health and resilience of these populations is uncertain. The capture data on Big Pine Key records the presences of adult males, adult females, and juveniles. This indicates that breeding and successful nesting is occurring there. The larger number of observed and captured skinks documented on Big Pine Key compared to other sites indicates that multiple individual skinks occur in this area (recaptures comprise approximately one third of the total). This site was selected for surveys because of the high quality and quantity of suitable FL Keys mole skink habitat. However, the high comparative count is believed to also be a reflection of the greater search effort taking place at this location (Figure 2-2; Table 3-2). Individual counts are low for the other three Keys known to have skinks. The presence and distribution of skinks being documented is highly reflective of the presence and effort of searches taking place at these locations. That is, individual skinks, and possibly more populations are present on the numerous other islands which have not yet been searched.

Population resiliency for the FL Keys mole skink populations is supported by the existence of available suitable habitat across the range of the subspecies. A strong correlation between habitat availability and population resilience is inferred but not at a certainty level where habitat can be used as a surrogate for skink presence. An example of this is Ohio Key, mentioned earlier, where surveys have failed to locate skinks even though suitable habitat exists on that Key.

Suitable coastal hammock and coastal dune habitat provides ground cover in the form of leaf litter and wrack material that skinks need for nesting, insect food sources, and cover. Mole skink abundance, distribution and life history behaviors (nesting, breeding) are limited to (and defined by) the availability of these resources in the remaining areas of beach berm and coastal hammock. While ground cover and insect food sources are apparently sufficient and occur in adequate amounts, there have been no quantitative studies completed on these factors. Valuable characteristics that contribute to population resilience are their generalist behavior in use of a) various ground covers and b) insect food sources.

Factors reducing population resiliency are the limited and patchily distributed suitable habitat and unconsolidated sandy soils available across the subspecies range. The islands of the Keys are limited naturally in their land mass. Much of the native coastal beach/hammock habitat has been developed and is highly utilized by human activities across the limited range of this subspecies. The availability of unconsolidated, dry soils is likely a limiting factor in the nesting success of the populations (Table 2-2). Currently, there are approximately 191 ha (472 acres) of sandy soils existing across six Keys in patch sizes ranging from approximately 1.8 to 30.6 ha (five to 76 ac). The small amount of naturally occurring beach habitat is highly developed. The habitat and soils are still believed to be in a quantity and quality enough to support the FL Keys mole skinks populations. However, stressors primarily from climate change and land development are currently adversely impacting these habitats and soils required by FL Keys mole skink populations.

Stochastic, passive dispersal of individual skinks among the islands of the Keys is highly likely to be occurring but is expected on a limited and random basis. The level at which immigration and emigration via dispersal acts as a factor facilitating population resilience and preventing extinction of this subspecies is unknown. The small size of many of the islands and the distance of water between them make the likelihood of dispersal appear limited in its influence on the population dynamics; however, it cannot be completely ruled out as a contributing factor. Many of the islands have yet to be searched, including some of the backwater islands. These island chains could be occupied, and it cannot be ruled out that they could act as “stepping stones” in the random dispersal of individual skinks. Genetic research on the Florida mole skink (all five subspecies) is currently underway, with a goal of furthering our understanding of population dynamics, genetic relatedness within the subspecies, and the degree of separation of this subspecies from the Florida mainland.

Heavy rainstorms, tropical storms, and hurricanes are part of this tropical island system, and these processes can be factors that reduce the resilience of skink populations. It may be one reason that the numbers of individuals across the Keys is historically and currently documented in low abundance. Individual skinks may colonize and occupy smaller Keys only temporarily until storm events impact that island. Eventual recolonization of impacted Keys by skinks is also uncertain. Examples of larger Keys that currently likely provide more persistent habitat and populations of skinks due to 1) a larger size, 2) available habitat that can buffer flooding effects, or 3) elevation (by a few meters) include Big Pine, Key West, the Dry Tortugas, and Long Key.

Because of the lack of available information on the extent of individual populations in the subspecies and the uncertainty of population structure, the assessment of population resiliency is incomplete. Resilient small numbers of skinks (most are single skink sightings) dispersed across the FL Keys are documented in historical and current records. Recent survey data from Big Pine Key found male and female adults and juveniles, indicating that breeding and some level of hatching success are taking place at this site. Available beach and coastal hammock habitat, ground cover, and insect food sources are patchily distributed across the range and are providing the resources to support skink populations; however, the FL Keys mole skink is still experiencing moderate to high stressors across its range from loss of habitat due to sea level rise (SLR) and human development. Environmental stressors from climate change pose a risk to the resilience of this subspecies as a result of habitat conversion or loss caused by inundation. The current limitation at the local level to directly manage, minimize or eliminate the causes of these global, climate-induced stressors contributes to this level of risk.

4.5.2 Subspecies Redundancy

Subspecies redundancy is expressed in its distribution and is often measured by the number of resilient populations. Redundancy in a system assists in subspecies' survival by providing a type of "backup". When a subspecies consists of multiple healthy (resilient) populations distributed across its range, it is most likely less vulnerable than if it only has a few populations or is just a single population. Distributed populations offer better redundancy than populations all occurring in close proximity and therefore, vulnerable to similar stressors of the same intensity or timing. This latter case is true for the FL Keys mole skink. Because of its limited geographic range, similar stressors are experienced with similar timing and intensity across its range. For example, the entire subspecies is vulnerable to the catastrophic effects of a hurricane passing over the Keys. Climactic shifts taking place in regional precipitation and temperature patterns also affect the subspecies as a whole.

Subspecies redundancy for the FL Keys mole skink is provided by individuals being distributed on many Keys and across the subspecies' known range. While there are currently only four genetically identified populations, species experts believe that low numbers of individuals (which may represent separate populations on each Key) do exist across the range of the species (Technical Team Working Group 2016; Tables 3-1 and 3-2). Generally, current searches are finding individual skinks in the Lower Keys on the same Keys that have historical records (Figure 2-2). In addition, recent surveys have also found skinks on Keys that do not have historical records of occurrence (such as Sawyer and Content Keys). In the Upper Keys, however, recent searches in Key Largo in areas with known historic records have failed to locate skinks. While the lack of findings in the Key Largo historical sites may be attributed to the difficulty of detecting skinks, it may also reflect a restriction of its range in the Upper Keys and a consequent decrease in subspecies redundancy compared to its historical condition. The most northern, recent documented skink sighting is from Long Key, approximately 50 km south (39 mi) of Key Largo.

Limited acreage of beach and coastal hammock habitats and unconsolidated soils exists in the Keys. This is a chain of small islands, and therefore, land mass in general is limited. In a sense, there is little redundancy or "backup" for the available suitable habitat, and natural expansion or movement of the subspecies to new areas is not possible.

Recent surveys have documented individual skinks (possibly not yet identified populations) on Keys that do not have historical records of skink occurrence. These skinks are not believed to be new recruits to these sites. It is more than likely that these are persistent individuals or groups of skinks on Keys that had never before been surveyed. The true spatial distribution of populations throughout the islands and islets of the Keys is unclear, and our current image of the subspecies distribution is based on the limited survey data. It is strongly believed that individual skinks occurring on Keys other than Big Pine, Boca Chica, Bahia Honda and Boot Key (those with genetically identified populations) either belong to a) one of the four identified populations, or b) additional genetically-distinct populations.

Dispersal of individuals among islands is random and likely an uncommon occurrence. Genetic evidence shows no sign of interbreeding between the identified populations. Surveys regularly observe or collect just a single skink or small numbers (less than 5), and it is possible that skinks do occur on other Keys but in low numbers. The importance of the other islands (other than those with identified populations) to the overall population resiliency for the subspecies is unclear. Skink surveys are very limited, and the subspecies may be distributed more broadly across additional Keys near the mainland as well as some of the larger, more remote backwater islands that hold suitable habitat and soils. Observations and searches by Refuge staff indicate the occurrence of at least some individuals on smaller islands, which are only accessible by boat and relatively remote (Table 3-2). These islands include Cook, Big Munson, Content, Sawyer, and the Marquesas. Both Cook and Big Munson are small islands with no road access but are in close proximity to Long Beach (both less than 1 mile away). Content, Sawyer and the Marquesas are remotely located from the mainland Keys.

Despite a level of redundancy provided by the discrete populations and individuals that are found dispersed across the islands, the FL Keys mole skink lacks a level of redundancy geographically because of its small endemic range. For some large scale stressors that affect the entire FL Keys archipelago, the entire subspecies is vulnerable to the timing and intensity of impacts. Large scale habitat loss is quite feasible during a strong hurricane as is direct mortality of skinks via drowning. On a localized, on-the-ground level, individual skinks would be expected to survive. Not all would drown, and some could opportunistically burrow under the soil or seek shelter in very small and protected areas. Others may become randomly dispersed on drifting material. It The occurrence of skinks on many of the Keys, even though in low abundance, provides some redundancy to the subspecies. Current stressors that impact the entire range of the subspecies are a) naturally occurring tropical storms and hurricanes and b) climate change stressors that include SLR, higher average hot temperatures, increased number of hotter days per year, more pronounced rainfall, shifts in seasonal precipitation patterns, increased flooding and storm surge events, and more intense major storms.

4.5.3 Subspecies Representation

Subspecies representation describes the ability of a species to adapt to changing environmental conditions and is measured by the breadth of genetic or environmental diversity within and among populations. Representation gauges the probability that a species (subspecies) is capable of adapting to environmental change. It is the evolutionary capacity or flexibility of the species (subspecies). Representation is the range of variation found in the species (subspecies), and this variation (called adaptive diversity) is the sources of the species' (subspecies') adaptive capabilities. Variation could occur genetically, across various ecotones, habitat types or elevations, for example.

The genetic and environmental diversity of this subspecies is low (Technical Team Working Group 2016; Mercier, K. Pers. Comm. 2017b; Branch et al. 2003, pp. 202-205). As mentioned, the FL Keys mole skink subspecies is a unique genetic lineage and is genetically distinct from the other mole skink subspecies. Evidence indicates that it is an isolated subspecies and not a population of the mainland subspecies (Parkinson et. al. 2016, pp. 12-13; Branch et al. 2003, pp. 202-205). There are no genetic signs of interbreeding between the other subspecies of mole skinks (Technical Team Working Group 2016; Mercier, K. pers. comm. 2017b). According to Branch 2003, pp. 202-205), nucleotide diversity and haplotype diversity is low in the FL Keys mole skink compared to populations of other subspecies. At this time, preliminary information suggests that the FL Keys mole skink subspecies is represented by at least four distinct populations, each on separate Keys, but as a whole, there is low genetic diversity within the subspecies (Mercier, K. pers. comm. 2017b). Also, there is no sign of morphological or behavioral differences between skinks on different Keys.

This island subspecies occurs across a narrow geographic and ecological range; there is no variation in habitat types across distance or elevation as occurs in wider-ranging and more abundant species. The entire subspecies is represented within the same tropical system within a range of approximately 378 km^2 (146 mi^2). Populations or individuals are represented across only slight elevation differences (a few meters) across the separate Keys. The amount of coastal sandy substrate and hammock habitat is limited and patchily distributed through the Florida Keys. The FL Keys mole skink does not occur across different ecotones and does not have access to different ecotones or systems in which to adapt.

This lack of breadth in the FL Keys mole skink makes is susceptible to events such as genetic mutations, diseases, or broad scale loss of habitat types. For example in the case of disease or parasites, one individual or population may spread disease or parasites to the entire subspecies if there is no variation that may protect some from being affected. No part (populations) of the subspecies is immune. The same case may occur environmentally, because the subspecies only occurs in a small range of tropical habitat. All individuals of this subspecies exist in the same system, and there are no other individuals or populations that exists in other ecosystems or varied environment (such as in a more temperate landscape). Therefore, if the tropical system is impacted, the entire subspecies is highly likely to be susceptible to impacts.

4.6 Summary of Subspecies - Overall Current Condition

The FL Keys mole skink has limited genetic and environmental variation (representation) within the Keys. The subspecies lives in this limited ecological setting, and there is no behavioral or morphological variation within the subspecies. Current searching has documented the subspecies from Long Key southwest to the Marquesas Keys, but no current records have been documented as far west as historical records on the Dry Tortugas or in the Upper Keys in the Key Largo area. Current distribution is only known from where current surveys are taking place. Therefore, there are data gaps on the subspecies' actual range-wide distribution and abundance. Despite the subspecies distribution across many Keys, it needs to be remembered that the overall distribution (redundancy) for this subspecies only occurs within the FL Keys. The FL Keys mole skink is a narrow-ranging endemic.

There are four identified populations and additional individuals (not yet identified into populations) occurring across separate Keys; however, little information exists on the abundance or growth rate of these populations (resiliency). Observation data indicates low numbers within populations. The largest and most consistently surveyed area, Long Beach on Big Pine Key, indicates that all life stages and breeding and nesting are occurring in this area. Populations or low numbers of individuals across the Keys have persisted through many hurricanes and severe storms that are part of this tropical ecosystem. Although available suitable habitat and soils that offer cover, nesting habitat, and food sources for the skinks exist across the range of the Keys, the FL Keys mole skink is still experiencing stressors from SLR, storms and flooding, and development across its range.

CHAPTER 5 - FUTURE CONDITIONS

5.1 Introduction and Summary

The low-lying archipelago of the FL Keys has experienced a SLR increase of approximately 0.08 m (3 in) since 1992 (NASA 2015, p. 2; NOAA 2017a). The primary stressors affecting the future condition of the FL Keys mole skink is SLR and associated climate change shifts in rainfall, temperature and storm intensities, and human development. These stressors account for indirect and direct effects at some level to all life stages and the habitat and soils across the subspecies' range. Additive climate change stressors projected for the future include: a) increased number and intensity of strong storms with associated storm surge, saltwater intrusion, and inland flooding, b) increased temperatures, c) shifts in the timing and amounts of seasonal precipitation patterns, and d) accelerated rates of SLR due to ice cap melt contributing to the Atlantic ocean current's influence on the East coast of the United States. Even if in the unlikely scenario that all other current stressors are nullified, the habitat of the Keys' is being inundated, and based on projections, coastal beach and low-lying areas will either be lost to the sea or converted to predominantly saltwater habitat.

The current and ongoing climate change stressors are the most influential threat to the subspecies future condition and status (Pearson et al. 2014, p. 217). Key life history factors of this subspecies which makes it vulnerable to climate change stressors are its small occupied areas, and low population sizes (Pearson et al. 2014, pp. 218-219). Global climate change is a natural process; however, the uncontrolled and continued release of large quantities of GHG emissions into our global atmosphere is accelerating global changes and affecting the planet's oceans. The rate and intensity of these global atmospheric warming processes have increased to a point that on a regional and local scale they have become negative stressors affecting the Keys' habitat.

To examine the potential future condition of the FL Keys mole skink, three future scenarios were developed. The scenarios focus on a range of conditions based on climate change scenarios and projections for land development. The range of what is likely to happen in each scenario will be described based on the current condition and how resilience, representation, and redundancy would be expected to change. The levels of certainty or uncertainty are addressed in each scenario.

Minor stressors were determined to remain relatively stable and not expected to change from current condition. These stressors include predation, collection, disease, pesticides, human disruption from human activities, and oil spills. If however any one of these stressors would begin to increase and place pressure on the subspecies, it will need to be immediately assessed. For example if it is found in the near future that individual mole skinks begin to experience symptoms of disease, a reassessment of the species condition would need to be reviewed.

As presented in the current condition, the rate of global SLR has been measured at approximately 0.003 m (0.12 in)/year since 1993 (NOAA 2017b, p. 8), and southeast Florida has shown a similar rate (Hall 2016; Compact, 2012, p.1). However, under future scenarios, the projected increase in SLR is not expected to continue on this same rate or trend. Recent information indicates that the rate of global and regional SLR is beginning to accelerate (Park and Sweet

2015, entire; NOAA 2017b, entire; Rahmstorf et al. 2015, entire; Zhang et al. 2011, entire). Both accelerated rates and higher inundation levels of SLR than previously projected are now expected to occur, especially along the East coast of the United States. Two main reasons for this are the: 1) Antarctica and Greenland ice melt adding ocean mass to the Atlantic Ocean, and b) thermal expansion of the oceans produced by warming seas (NOAA 2017b, pp. 7,16; Deconto and Pollard 2016, p. 596; Park and Sweet, 2015, entire).

NOAA (2017b, entire) recently reviewed past projections compared to current levels of SLR, and the updated comparison indicates that the actual SLR taking place is trending on the high end of 2009 projections. Therefore, NOAA (2017b, entire) has modified the Low, Medium and High bounds to the global SLR projections. The projected lower bound for global SLR by 2100 is now 0.3 m (11.8 in) (was 0.1 m[3.9 in]) and the upper bound is now a projected 2.5m (8.2 ft.) by 2100 (was 2.0 m [6.6 ft.]) (NOAA 2017b, p. 14; Figure 5-1; Appendix D).

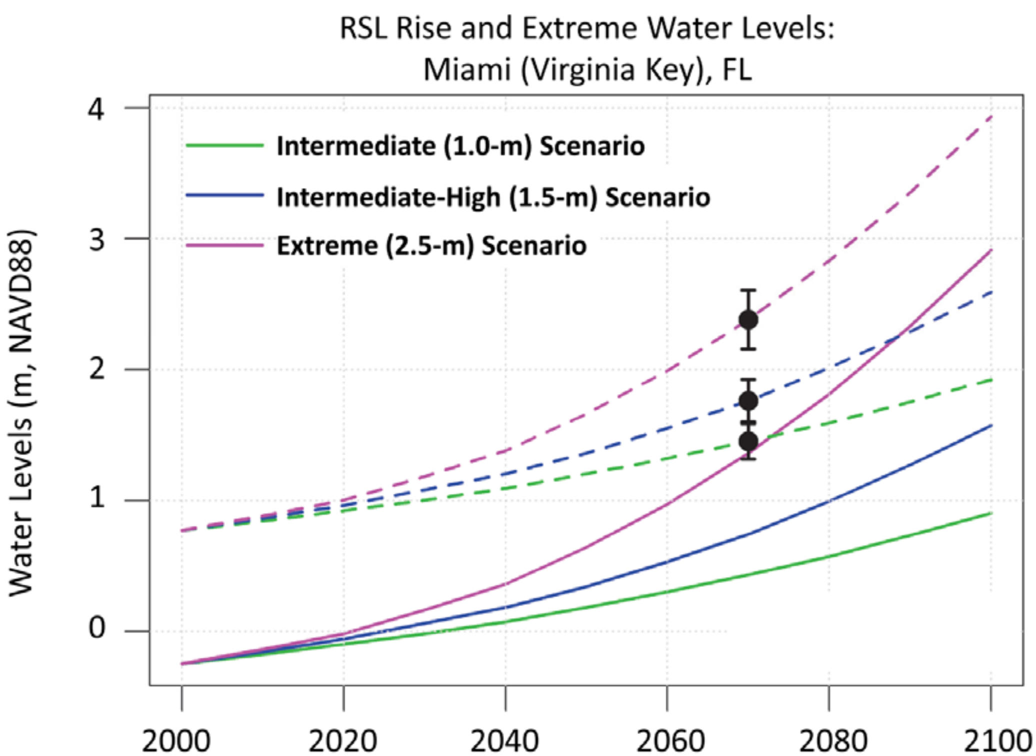


Figure 5-1. Relative sea level rise for Miami (Virginia Key), FL based on NOAA 2017b (p. 40) (solid lines). Dashed lines indicate a worst case scenario of a King tide with a 1% annual chance of occurring (95% confidence intervals for year 2017 = black error bars). Curves are based on use of geodetic datum NAVD88 using the tidal data at Key West.

NOAA (2017b, entire) developed six global MSL scenarios to 2100 (Low, Intermediate-Low, Intermediate, Intermediate-High, High, and Extreme). There is an approximately 100 percent likelihood of exceeding the low (0.30 m)(11.8 in) global SLR curve by 2100 (NOAA 2017b, p.33; Figure 5-1). There is a reported 0.05 to 0.1 percent likelihood of exceeding the extreme curve (2.5m)(8.2 ft.) by 2100 (NOAA 2017b, p.21). Current GHG emissions remain high which places the trend in SLR on the higher end of projections (Compact 2012, p.33). As well, any mitigation actions that may be implemented will not be able to influence the path of the climate shifts prior to 2060 (Compact 2012, p.33). While the likelihood of reaching the Extreme projection of 2.5 m (8.2 ft.) by 2100 is low, reaching this level of inundation would mean great negative consequences for life and property (high risk).

Observed and projected changes in climate at the regional level vary from global average conditions. The SLR projections used in this assessment were "downscaled" from the global scale projections. Regionalized projections provided higher resolution information that is more relevant to spatial scales used for analyses of the FL Keys mole skink and the conditions influencing it and its habitat.

Regional south FL SLR projections were used to develop GIS shapefiles to view and run computer scenarios of the projected SLR over time (Univ. of FL 2015). This mapping also provided an illustrative view of inundation on the FL Keys landscape based on these projections. The projections include a Low, Medium and High scenario of SLR to 2100 at the regional level. Further information on the development of these projections can be found in Univ. of FL (2015).

These regional projections were used to define the future scenarios of this assessment. They were adjusted (downscaled to a regional level) from the Global "worst", "moderate", and "best" case SLR scenarios (IPCC 2013; NOAA 2017b). There are numerous SLR modeling projections developed to reflect the range in of the "worst", "moderate, and "best" case GHG scenarios. The "worst" case represents a "global business as usual" scenario. The "moderate case" represents a scenario that "begins global moderate reduction in GHG concentrations by 2015, then decreasing", and the "best" case scenario is to "begin aggressive global GHG reductions now" (IPCC 2013, entire; NOAA 2017b, entire; Hall et al. 2016, entire; Jevrejeva et al. 2014, entire; Parris et al 2012, entire). Appendix D provides a summarized list of some of the published SLR projection curves.

In FL, SLR by 2100 is projected to have increased to between 0.3 m (1 ft.)(low) to 2.5m (8.4 ft.)(high)(NOAA 2017b, p.40). The regional Geoplan projection which do not yet account for the accelerated rates predict a 0.13 m (5 in) to 1.6 m (63 in) SLR by 2100 for south Florida (Univ. of FL 2015).

The Low, Medium, and High SLR scenarios of Southeast FL, including the Keys, for 2040, 2060, and 2100 (Univ. of FL 2015)(Geoplan) were used in the description of three future scenarios for the FL Keys mole skink (Table 5-1; Figure 5-2)(U.S. Army Corps of Engineers [USACE], 2014). A 2020 curve was not used in the future scenarios for the FL Keys mole skink, because this near-future scenario is not reflecting a large enough difference between the current conditions.

A FWS Staff Working Group consisting of a meteorologist, GIS specialist, and biologists compiled and analyzed the information for the future conditions assessment, and this information was reviewed by the Technical Team Working Group. These projections do not yet reflect modeling based on new increased rate estimates (which are approximately 15% higher based on the NOAA 2017b, entire). However, GIS mapping shapefiles were available from the Geoplan (Univ. of FL 2015) data which allowed for viewing of inundation levels across the Keys in time lapse images. The spatial information was able to be used to visually observe and calculate changes to land area, habitat, soils, and FL Keys mole skink observation data based on various levels of inundation.

Table 5-1. Estimated south FL SLR projections used for the FL Keys mole skink Future Scenarios. See Figure 5-2 for graphical depiction.

Estimated Relative South Florida Regional Sea Level Change Projections. meters (in) (ft.)				
	2020	2040	2060	2100
Low	0.1 (3.9)	0.13 (5)	0.18 (7)	0.28 (11)
Medium	0.1 (3.9)	0.2 (8)	0.3 (12) (1 ft.)	0.61 (24) (2 ft.)
High	0.2 (7.9)	0.38 (15) (1.25 ft.)	0.71 (28) (2.3 ft.)	1.6 (63) (5.25 ft.)

(Univ. of FL GeoPlan 2015). Shaded beige = same or similar 0.2m (8 in) inundation values. Shade blue = same or similar 0.3m (1 ft.) inundations.

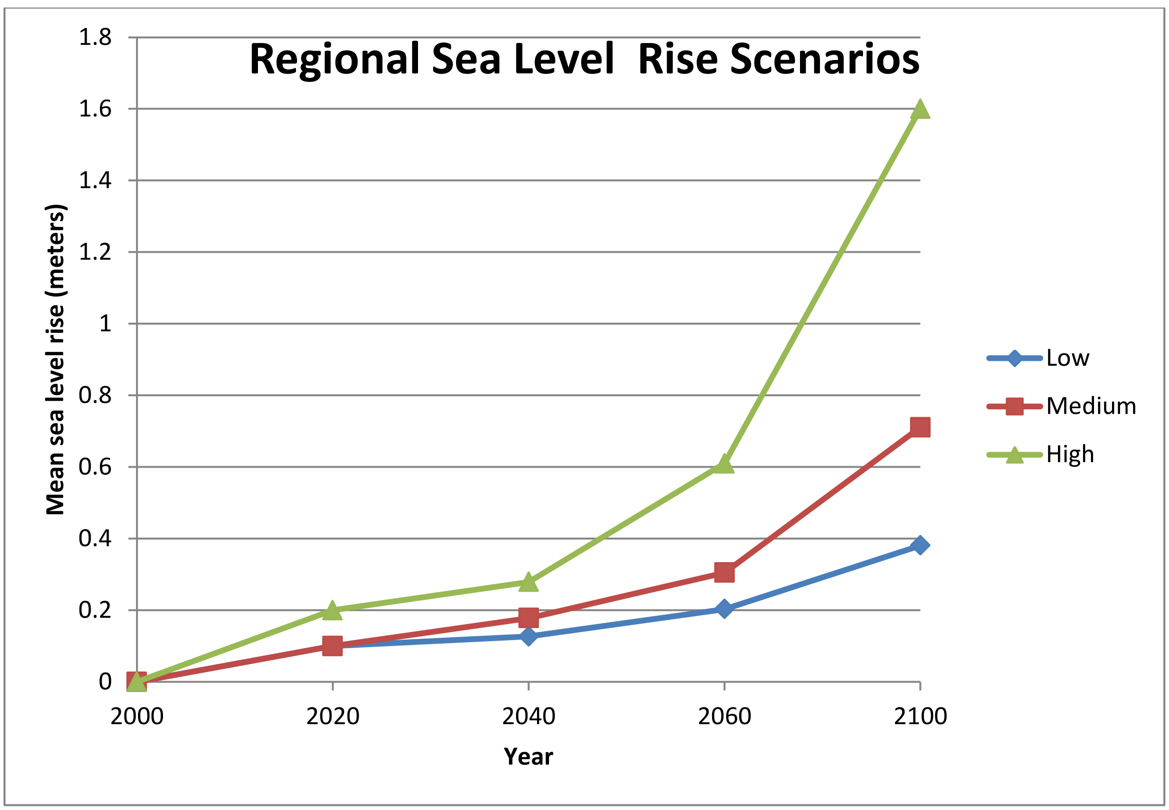


Figure 5-2. Estimated south FL SLR projections used for FL Keys mole sink Future Scenarios.

The work of Pearson et al. (2014, entire) was also considered in assessing future scenarios. Pearson et al. (2014, entire) used life history, spatial, and demographic variables (such as population size and connectivity) in models used to predict the extinction risk due to climate change of thirty six reptile and amphibian species. The two variables found to be most influential in predicting extinction risk due to climate change were "occupied area" and "population size" (Pearson et al. 204, pp. 18-19). The interaction of specific variables was also a determinant in the risk of extinction. For example, the effect a population size (small populations with higher risk than larger populations) from climate change was found to be magnified for species with small occupied areas (Pearson et al. 2014, p. 218). This work indicated that the same life history and population variables (such as population size and connectivity) typically used to predict effects of the stressors to the species can be used in the same manner for reviewing effects of climate change stressors on a species.

5.2 Future Scenarios

…In risk assessment, the range of plausible scenarios need to be considered, including those that are most likely to occur but may not result in extreme impacts, as well as those with a lower probability of occurrence but may have potentially consequential outcomes. We must responsibly consider the "worst case scenario" when consequences, even if risk is low, are severe or catastrophic if took place. (NOAA 2017b, p. 5, 34)

Three feasible future scenarios representing Best, Moderate, and Worst case scenarios for the FL Keys mole skink followed the Low, Medium, and High regional climate change SLR projections, respectively, as developed by the Univ. of FL under their Geoplan project (2015) (Table 5-4).

Also, for all three future scenarios, the IPCC's description and likelihood of occurrence in the 21st century of extreme weather and climate events including changes in temperature, precipitation, and storm intensity was used (Table 5-2)(IPCC 2013, p. 7). The level of occurrence or trends of these events are generally presented as positively occurring or not, and are not shown in a low, medium, and worst case scenario; therefore this same set of projected weather events and their likelihood trends was used in each of the future scenarios for the FL Keys mole skink. In addition, most of these events most directly associated with the Florida Keys (more hot days, increase in precipitation events, and increase in storm intensity) are already being documented, and there is a high confidence in their occurrence into the late 21st century. The IPCC terms used to describe the likelihood of the event are described in Table 5-3.

Table 5-2. IPCC global scale assessment of extreme weather and climate events and likelihood of further changes in the 21st Century (IPCC 2013, p. 7 Table SPM.1 summarized).

Weather and climate events and trend	**Likelihood of further changes**	
	Early 21st Century	**Late 21st Century**
Warmer and/or fewer cold days and nights over most land areas	Likely	Virtually certain
Warm spells/heat waves. Frequency and/or duration increases over most land areas	Not formally assessed[a]	Very likely
Heavy precipitation events. Increase in the frequency, intensity, and/or amount of heavy precipitation.	Likely over many land areas	Very likely over wet tropical regions.
Increases in intensity and/or duration of drought	Low confidence[b]	Likely on a regional to global scale
Increases in intense tropical cyclone activity	Low confidence	More likely than not
Increased incidence of extreme high sea level	Likely	Very Likely

[a]Models project near-term increases in the duration, intensity, and spatial extent of heat waves and warm spells.
[b]There is low confidence in projected changes in soil moisture.

Table 5-3. IPCC Fifth Assessment Report (AR5) Likelihood Terms (IPCC 2013, p. 142).

Term	**Likelihood of the Outcomes**
Virtually certain	99–100% probability
Very likely	90–100% probability
Likely	66–100% probability
About as likely as not	33–66% probability
Unlikely	0–33% probability
Very unlikely	0–10% probability
Exceptionally unlikely	0–1% probability

*Additional terms that were used in limited circumstances in the Fourth Assessment Report (AR4) (*extremely likely* = 95-100% probability, *more likely than not* = > 50% -100% probability, and *extremely unlikely* = 0-5% probability) may also be used in the AR5 when appropriate.

In each of the following scenarios, population growth and development possibilities were considered. While there are differing future options for development, the highest (or worst) level of projected development even in the positive growth scenario does not act as a major stressor as compared to the climate change stressors. Two reasons for this are the 1) amount of protected lands and 2) county building regulations which currently exist in the FL Keys. The minor stressors discussed in the current condition were considered and it was determined that these stressors will remain at the same or similar level similar to the current under the future conditions. That is, these stressors will not increase or rise to the level of impacting the 3Rs for the FL Keys mole skink.

The future scenarios are based on the projected inundations presented in Table 5-4 (I. Best Case Scenario, II. Moderate Case Scenario, and III. Worst Case Scenario). Figure 5-3 illustrates the Low, Medium and High 2040 to 2100 projected sea level rise curves used, respectively, in describing the "Best", "Medium" and "Worst" case scenarios for the FL Keys mole skink (Univ. of FL 2015) (Table 5-4 I, II, and III). Due to the difficulty of displaying the entire range of the FL Keys, the select Keys of: Key Largo (Upper Keys), Long Key (Upper Keys), Big Pine Key (Middle Keys) and Key West/Boca Chica (Lower Keys) are shown. Additional illustrations of habitat change under these three scenarios of these same Keys are provided in Appendix E.

Table 5-4.

I. Best Case Scenario

	Climate Change	*Land Development/Habitat Conversion*	*Other Stressors*	*Likelihood of modified GHG emissions (IPCC Guidance)*
Best Case Scenario Description	Low emission Strong mitigation to decrease emissions by end of the 21st century Low SLR curve – 0.13m (5 in) to 0.28 m(11 in) from 2040 to 2100 Table 5-1; Univ. of FL 2015. NOAA (2017b) Low 0.3 m (11.8 in) SLR by 2100 Likelihood of exceeding by 2100 is 100%. Per IPCC (2013, pp.7 and 142) for all scenarios: • Precipitation – Increased number of consecutive dry days. (*likely*). • Stronger storms (increased magnitude) and with heavier downpours (*very likely).* • Temperature: More days higher than 95 degrees F (*virtually certain*). For coastal FL this means an additional 30-50 days a year above 95 degrees F.	Reduced trend or remains the same as current trend but increased densities are only approved in already developed urban. Lower rate of SLR is expected to keep growth rate up or the same. Or, as SLR effects are noticed, a "flattened" or a lowered population growth is expected. More likely best case is the lower rate of SLR and the same or higher increase in population.	Likely at same level Disruption, destruction of habitat from tourism, recreational activities is maintained at current level (status quo) Effectiveness of management on existing protected lands is improved to assure persistence of species and habitat Presence of exotics (fire ants, veg;, feral cats, snakes)	Very unlikely – Will likely exceed these projections. This scenario is similar to the IPCC RCP2.6 * (low curve). (Appendix D) *RCP is Representative Concentration Pathways (= GHG concentrations)

II. Moderate Case Scenario

	Climate Change	*Land Development/Habitat Conversion*	*Other Stressors*	*Likelihood of modified GHG emissions (IPCC Guidance)*
Moderate Case Scenario Description	Moderate emissions Moderate mitigation GHG emissions stabilized by 2050, then decreasing Medium SLR curve: 0.2m (8 in) to 0.61m (26 in or 2ft) from 2040 to 2100 (Table 5-1; Univ. of FL 2015). NOAA (2017b) Medium SLR - Likelihood of exceeding by 2100 is 50 percent. Per IPCC (2013, pp.7 and 142) for all scenarios: • Precipitation – Increased number of consecutive dry days. (*likely*). • Stronger storms (increased magnitude) and with heavier downpours (*very likely)*. • Temperature: More days higher than 95 degrees F (*virtually certain*). For coastal FL this means an additional 30-50 days a year above 95 degrees F.	Current trend of 5.9% with no predevelopment densities. Status quo	Likely at same level Disruption, destruction of habitat from tourism, recreational activities is maintained at current level (status quo) Effectiveness of management on existing protected lands is improved to assure persistence of species and habitat Presence of exotics (fire ants, veg;, feral cats, snakes)	Likely as not This scenario is similar to the IPCC RCP 4.5 (Intermediate -low curve). (Appendix D)

III. Worst Case Scenario

	Climate Change	*Land Development/Habitat Conversion*	*Other Stressors*	*Likelihood of modified GHG emissions (IPCC Guidance)*
Worst Case Scenario Description	High emission, temperature, precipitation, SLR Business as Usual High SLR curve: 0.38 m (15 in or 1.25 ft.) to 1.6 m (63 in or 5.25 ft.) from 2040 to 2100 -- without accelerated rates modeled.* (Table 5-1; Univ. of FL 2015) *At this time, 0.05 to 0.1 percent likelihood chance of exceeding Extreme 2.5 m by 2100 from NOAA (2017b, p. 21). Using current accelerated rates. Lower Probability but High Risk/Consequences to this scenario. Per IPCC (2013, pp.7 and 142) for all scenarios: • Precipitation – Increased number of consecutive dry days. (*likely*). • Stronger storms (increased magnitude) and with heavier downpours (*very likely)*. • Temperature: More days higher than 95 degrees F (*virtually certain*). For coastal FL this means an additional 30-50 days a year above 95 degrees F.	Increase in current population trend and no predevelopment densities (full build-out of available lands)	Disruption, destruction of habitat from tourism, recreational activities is maintained at current level (status quo) Effectiveness of management on existing protected lands is improved to assure persistence of species and habitat Presence of exotics (fire ants, veg;, feral cats, snakes)	Not as likely to exceed this by 2100. Current future projection gives a 0.05 to 0.1 percent likelihood of being exceeded by 2100. Does not rule out reaching it beyond 2100. This scenario is similar to the IPCC RCP8.5 (High curve). (Appendix D)

Low, Medium, and High 2040 to 2100 SLR Projections for Key Largo, Long Key, Big Pine, Key West and Boca Chica (Univ. of FL 2015)

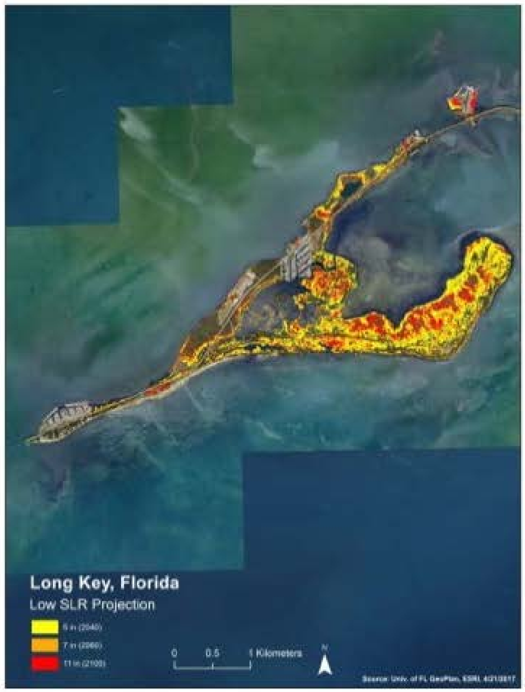
Key Largo

Low

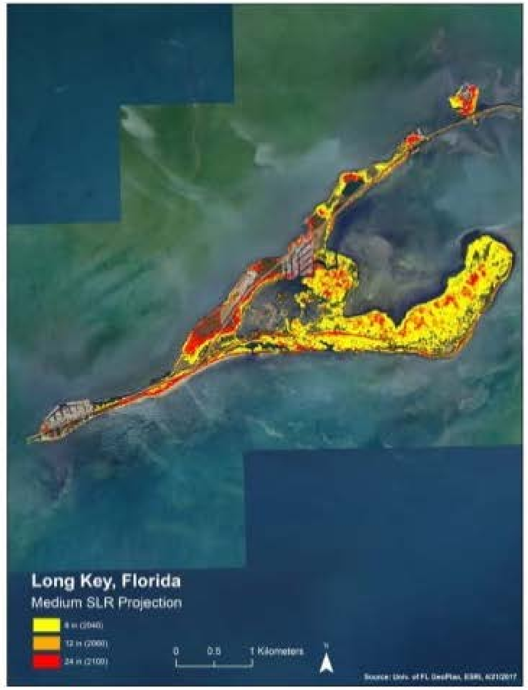
Medium

High

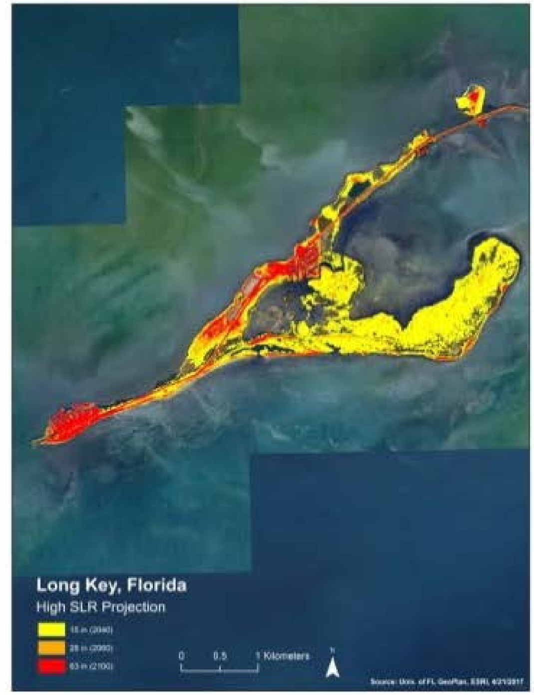
Long Key



Low

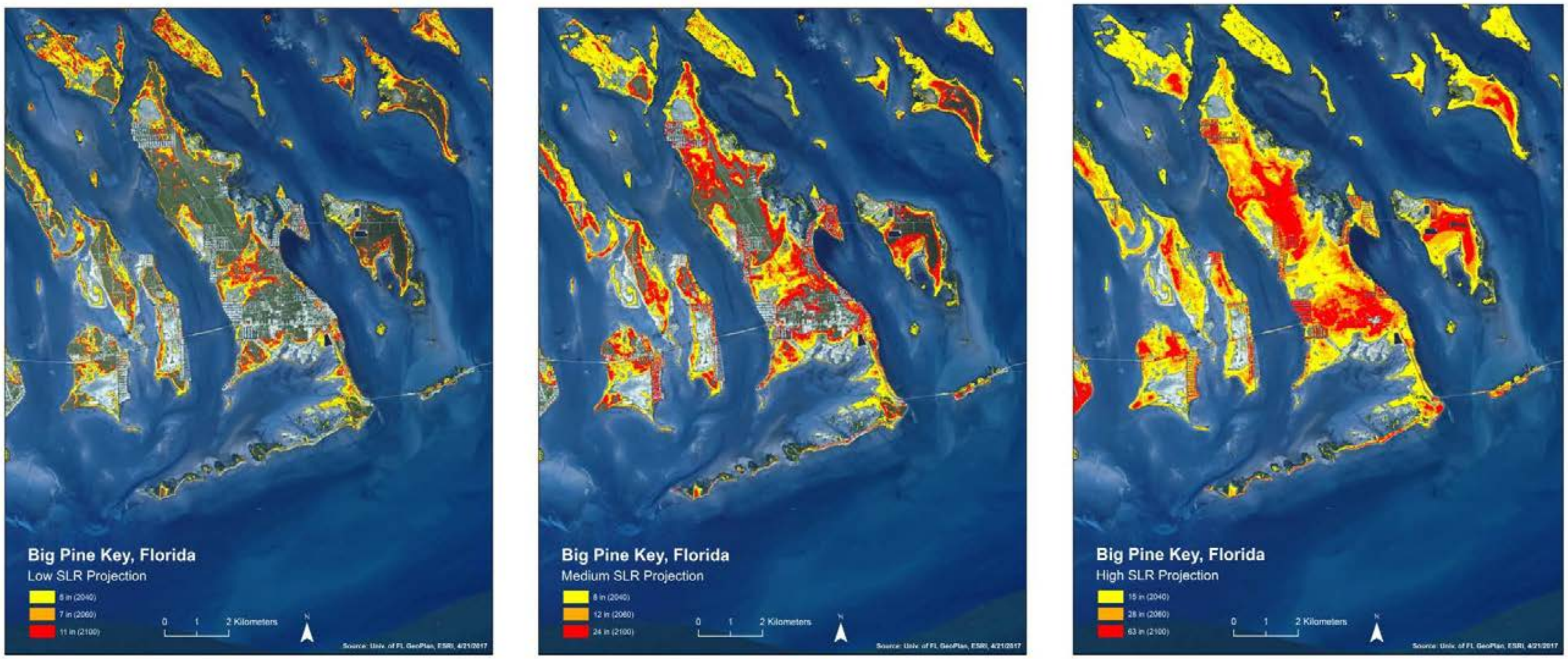


Medium



High

Big Pine Key



Low Medium High

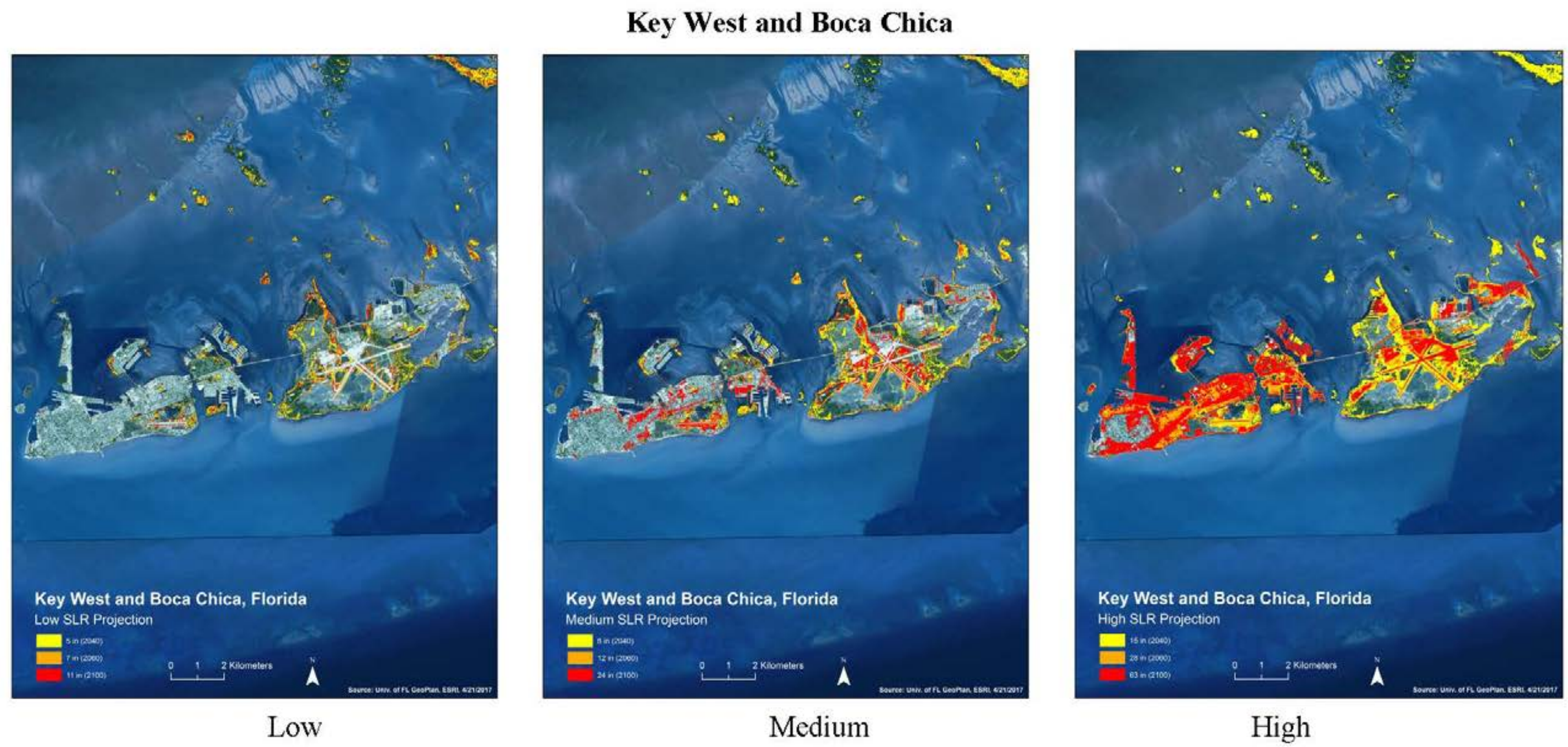


Figure 5-3. Low, Medium and High 2040 to 2100 projected sea level rise curves used, respectively, in describing the "Best", "Medium" and "Worst" case scenarios for Key Largo (Upper Keys), Long Key (Upper Keys), Big Pine (Middle Keys), and Key West and Boca Chica (Lower Keys).

5.2.1 Projected Changes in Temperature and Precipitation

The future scenarios include the projected changes in temperature and precipitation resulting from climate change in the south FL region. The projected increases in average annual temperature by the late 21st century compared to the late 20th century vary from +3 to +7° F (statewide depending on location and the emissions scenario used). Extreme heat events in FL are projected to increase relative to 1986-2005. By the late 21st century, the average temperatures on the hottest days will be 3º to 8° F hotter. Due to the already released, human-induced emissions of GHGs present in the environment, another +0.5° F increase in surface air temperature would be expected, even if there was a sudden end to all human-induced GHG emissions (Carter et al. 2014, p. 25). From 2041 to 2070, the FL coastal area is projected to experience approximately 30 to 40 more days/year with temperatures above 95° F compared to recent historic levels (1971-2000) (Figure 5-4).

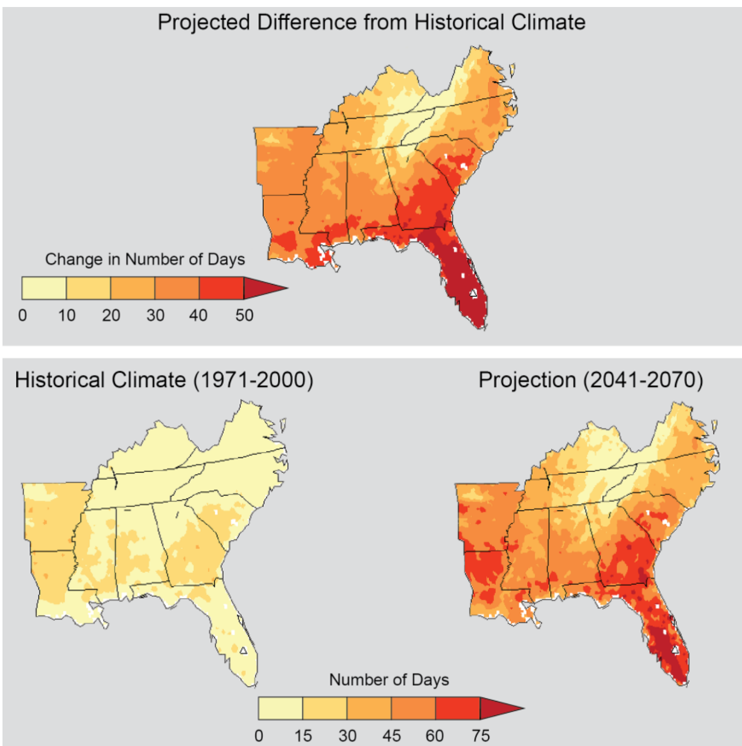


Figure 5-4. Projected average number of days/year with temperatures above 95° F for 2041-2070 compared to 1971-2000. (Carter et al. 2014, Figure 17.4, p. 399).

Precipitation projections are less certain, but many models project increases in precipitation during the Wet Season (rainy season) across southern FL and the Caribbean (USFWS 2017, pp.2-5). Projections of future changes in precipitation show substantial shifts in where and how precipitation will fall. Rainfall in the FL Keys is expected to increase by approximately 20 percent in the Fall, 10 percent in the Winter, and 30 percent in the Summer. Spring precipitation is projected to decrease by ten percent (Walsh et al. 2014, pp. 32-34).

Dry consecutive days are expected to increase up to 30 percent in south Florida by 2100. While dry conditions are preferred for the FL Keys mole skink, extreme conditions (lack of rainfall and increased temperatures) are detrimental. For example, prolonged periods of drought or decreased precipitation across a tropical ecosystem create losses in vegetative cover and an increased risk to the subspecies due to desiccation.

Storm Events

Models are in agreement regarding changes in tropical storm and hurricane rainfall events. Greater rainfall rates are expected with about a 20 percent increase near the center of storms. Scientists continue to research the expectation of precipitation changes in other severe storms (USFWS 2017, pp 4-5). Tropical storms and hurricanes are projected to be fewer in number but stronger in force, with more Category 4 and 5 hurricanes (Walsh et.al. 2014, p. 20). Almost all existing studies project greater rainfall rates in hurricanes in a warmer climate, with projected increases of about 20 percent average near the center of hurricanes (USFWS 2017, p. 7). Stronger storms (increased magnitude) and with heavier downpours are considered "*very likely*" based on the IPCC (2013, p. 7).

5.2.2 Population Growth and Development

The July 2016 estimated human population of Monroe County, FL was 79,077 individuals, an 8.2% increase from the April 2010 population estimate of 73,090 (United States Census Bureau [U.S. Census Bureau] 2017). The estimated density from the most recent census in 2010 was 28.7 people per km^2 (approximately 74.3 people per mi^2) (U.S. Census Bureau 2017). This current estimated population is above the estimated 2060 population of 77,038 people made by Carr and Zwick (2016, p.28). Monroe County slightly exceeded this 2060 projection in 2015.

The current growth rate for Monroe County is still considered "medium" compared to many other Florida counties, and there is a record of population decline in Monroe County from 2000 to 2010 (Carr and Zwick 2016, p.28). The population dropped 8.2 % (from 79,589 to 73,090) (U.S. Census Bureau 2017) before returning to the positive growth rate currently observed. An assessment of climate change on the FL Keys by Hoegh-Guldberg (2010, p. 14) assumed that the population of the Keys is directly related to the remaining land area. Consequently, as land area is reduced, the number of persons in the Keys would be expected to decline.

Based on this information, feasible population growth scenarios include the 1) continued increase in population, 2) no change in current population (increases and reductions maintain current population), or a 3) decline in the population. In terms of population increases, Carr and Zwick (2016, p. 9) presented two alternatives. One is the current trend in which new populations are not accommodated to the existing urban areas. That is, growth has some capability of moving into new areas because of the density limitations in the existing urban areas. The alternative is the use of "redevelopment areas". This is the accommodation of new populations "through an increase in the densities of existing urban areas" (Carr and Zwick, 2016. p. 9). This 2070 alternative allows more people in already existing, urban areas, reducing new development into undeveloped areas. Despite the alternatives to increasing density in some areas to reduce development in more undeveloped areas, the Keys still has a limited carrying capacity especially with SLR currently reducing the total available land mass.

Zwick and Carr (2006, p.15) predicted with a population of approximately 92,200 people that no vacant land in the Keys would remain. This information does not consider the millions of people who visit the Keys as tourists and temporary visitors each year. The increase in the human population and consequent development and pressures this exerts on the Keys is expected to intensify as inundation and increased flooding events occur. Inundation and increased incidences of flooding events will trigger people to move to higher ground. At some point, the population could be expected to decline in order to accommodate the loss of land mass and consequential negative effects on property values and the economy (Hino et al. 2017, entire; Zhang et al. 2011, pp. 9-17). While population increase is a stressor on the natural habitats needed by the FL Keys mole skink, the most immediate and unchecked threat is the impact of SLR and subsequent loss of habitat for the subspecies across the range.

5.3 Expected Changes; Implications to the 3Rs

The preferred habitats (identified as beach berm and coastal hammock) and soils (identified as Beach sand and Bahia Fine Sand) for the FL Keys mole skink were analyzed according to expected losses from projected sea level rise using the Univ. of FL (2015) best, moderate, and worst case scenarios (Table 5-5; Appendix E).

Table 5-5. Monroe County Florida total land mass, and FL Keys mole skink suitable habitat and soils SLR under the Low (2040), Medium (2060) and High (2100) projected inundation curves.

SLR Projected Low(L),Medium(M), High (H)		**Total Land hectare(ha) (acres (a))**	**Hectare (acres) inundated**	**Percent hectare (acres) inundated**
All Keys – Monroe County meters (in) (ft.)		36,006 (88,973)		
0.13 (5)	2040L		4463 (11028)	12
0.2 (8)	2040M		6502 (16066)	18
0.38 (15) (1.25)*	2040H		9513 (23506)	26
0.18 (7)	2060L		6037 (14917)	17
0.3 (12) (1)*	2060M		8407 (20773)	23
0.71 (28) (2.3)	2060H		13010 (32150)	36
0.28 (11)*	2100L		8078 (19962)	22
0.61 (24) (2)	2100M		11986 (29620)	33
1.6 (63)(5.25)	2100H		18202 (44978)	51
Beach Berm and Coastal Hammock Habitat m (in)(ft.)		3669 (9067)		
0.13 (5)	2040L		81 (201)	2
0.2 (8)	2040M		186 (459)	5
0.38 (15) (1.25)	2040H		631 (1558)	17
0.18 (7)	2060L		154 (381)	4
0.3 (12) (1)	2060M		403 (997)	11
0.71 (28) (2.3)	2060H		1599 (3951)	44
0.28 (11)	2100L		352 (871)	10
0.61 (24) (2)	2100M		1337 (3303)	36
1.6 (63) 5.25)	2100H		2727 (6739)	74
Beach and Bahia Fine Sandy Soils m (in)(ft.)		155 (~384)		
0.13 (5)	2040L		30 (74)	19
0.2 (8)	2040M		42 (103)	27
0.38 (15) (1.25)	2040H		58 (143)	37
0.18 (7)	2060L		39 (97)	25
0.3 (12) (1)	2060M		52 (128)	33
0.71 (28) (2.3)	2060H		78 (193)	50
0.28 (11)	2100L		50 (124)	32
0.61 (24) (2)	2100M		72 (178)	46
1.6 (63)(5.25)	2100H		111 (274)	71

*Similar 0.3 m (1 ft.) inundation levels.

In the best case future scenario (Low 2040-2010 SLR curve) for the FL Keys mole skink, approximately 12 to 22 percent of the total land in the Keys is expected to be inundated from 2040 to 2100 (this is a conservative estimate using the Univ. of FL (2015) projections (Table 5-5; Figure 11 -14). The Univ. of FL (2015) SLR curves are in the mid-range of existing modeled SLR projections (Appendix D). For example, the most recent NOAA (2017b) SLR projections downscaled regionally give High curves above those of the regional Univ. of FL (2015) curves.

The Low SLR curve (projection) is considered to have a near one hundred percent probability of being exceeded (NOAA 2017b, p. 33). The best case scenario would be to not reach or have no more than this expected inundation. Approximately 2 to 10 percent and 19 to 32 percent of FL Keys mole skink preferred habitats and soil, respectively, are projected to be inundated under the best case scenario (low curve) from 2040 to 2100. As mentioned, these projections are more conservative and do not yet incorporate recent adjustments in the modeling for the accelerating rate of global and regional SLR. Under the NOAA (2017b) projections which do account for the accelerated SLR rate (Appendix D), the best case scenario (low curve) projects a higher range of inundations, from 0.13 m (5 in) to 0.3 m (1 ft.) during this same time. The medium future scenario for the FL Keys mole skink projects 18 to 33 percent of the land (0.2 m [8 in] to 0.61 m [2 ft.] SLR) is inundated between 2040 and 2100 (Table 5-5).

Depending on the actual rate of SLR taking place in the future (whether the actual inundation levels follow more closely to a low, medium, or high projection) the range of the total acreage of land loss in the Keys by 2040 is projected to be between 12 to 26 percent. Between 26 to 51 percent of all of the land in the Keys (mapped to include Monroe County and above Key Largo in Miami-Dade County) are projected to be inundated by 2100 (Table 5-5).

Suitable habitat and suitable soils are projected to decline between 2 to 17 percent and between 19 to 37 percent, respectively by 2040. At the projected 2040 High (0.38 m; 15 inches), 17 percent of the FL Keys mole skink suitable habitat is inundated across the Keys in Monroe County. At the projected 2060 High (0.7m; 28 in), approximately 44 percent of the suitable habitat is inundated across the Keys. Seventy four percent of the FL Keys mole skink suitable habitat is projected to be inundated at 1.6 m (63 in; 5.3ft.)(2100 High curve)(Table 5-5).

Figures 5-5, 5-6, 5-7, and 5-8 provide illustrative maps for Key Largo (Upper Keys), Long Key (Upper Keys), Big Pine Key (Middle Keys) and Key West (Lower Keys) at 0.13 m (5 in), 0.3 m (1 ft.), 0.61 m (2 ft.), and 1.6 m (5.25 ft.)(the 2100 High) of inundation. The same inundations are also illustrated for Long Key located in the Middle Keys, a Key which has the largest amount of mapped sandy soils in the range of the FL Keys mole skink and the most-northern recently documented skink observation (Figure 2-2). A 0.13m (5 in) inundation is equivalent to the projected low curve at 2040. A 0.3 m (1 ft.) of SLR is equivalent to the 2040 High, 2060 Medium, or 2100 Low, and 1.6 m (5.25 ft.) is the highest inundation of the worst case scenario (2100 High Curve). There is some uncertainty on the timing of inundation levels as they are projected in to the future. A one foot inundation may be experienced from 2040 to 2100, depending on the rate of SLR. Therefore, despite some uncertainty on the timing of the inundation, it is important to understand the implications between different levels of SLR to the land mass, habitat and soils. Losses to the landscape from inundation increase exponentially from 0.13m (5 in) of SLR to 0.3 m (1 ft.) and 0.6 m(2 ft.(Figures 5-5, 5-6, 5-7, and 5-8).

The Keys are projected to get to at least one ft. of SLR by 2040 at the worst case SLR curve (observed SLR is currently trending on the high end of the curves), by 2060 at the medium scenario curve, and by 2100 under the best case SLR curve (Univ. of FL 2015)(Figures 5-5, 5-6, 5-7, and 5-8). At one ft. of SLR, 61 percent of Monroe County's land mass is vulnerable to SLR (SE FL Regional Climate Change 2012, p. vii). Using the work of The Nature Conservancy (2010, entire), Hoegh-Guldberg (2010, p. 13), projects that approximately 70 percent of the land in the Keys will be lost with 0.35 m (1 ft.) of SLR. At one ft. of SLR, 61 percent of Monroe County's land mass is vulnerable to SLR (Compact 2012, p. vii).

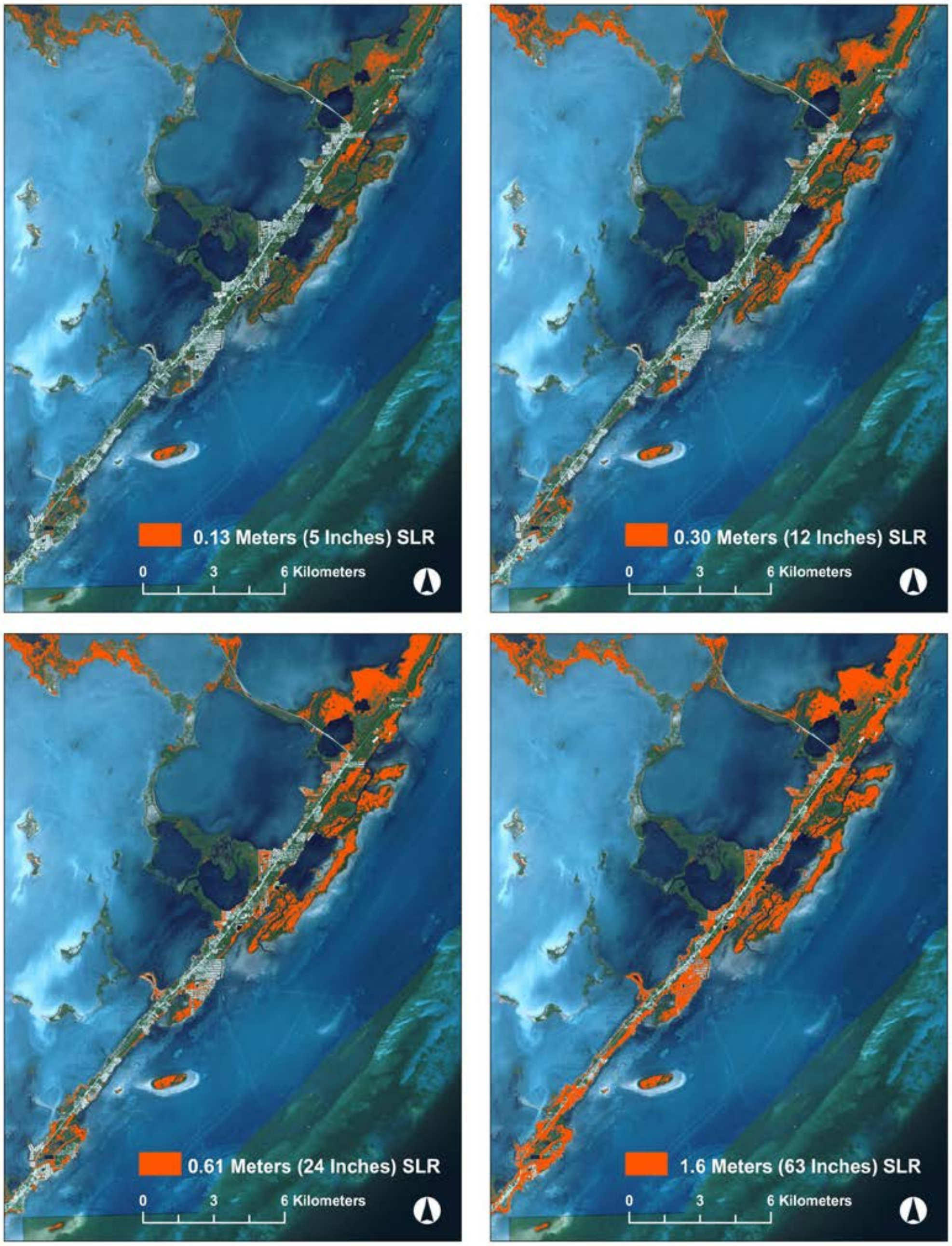


Figure 5-5. Key Largo 0.13 m (5 in), 0.3 m(1 ft.), 0.6 m (2 ft.), and 1.6 m (5.25 ft.) Sea Level Rise Projections (Univ. of FL 2015)

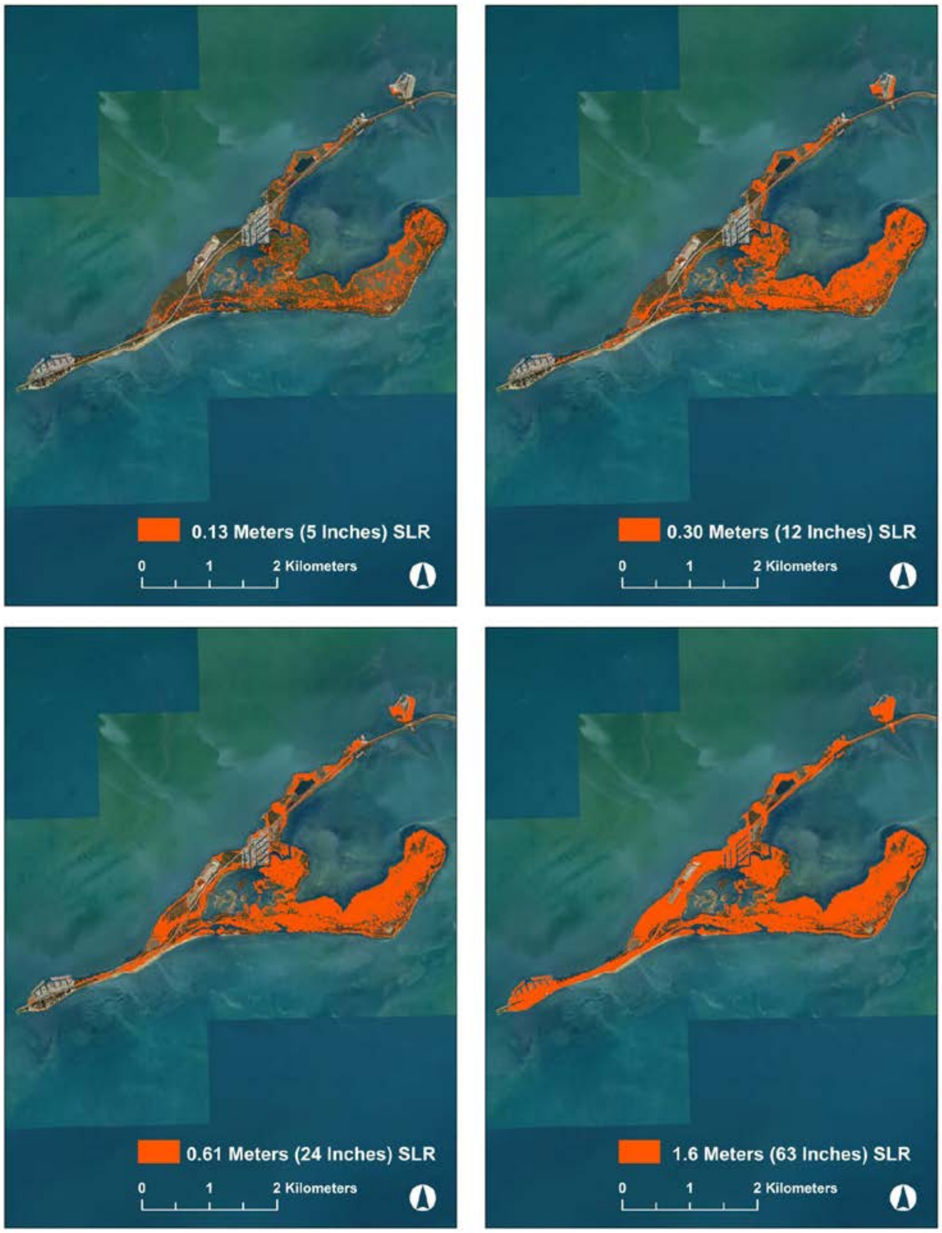


Figure 5-6. Long Key 0.13 m (5 in), 0.3 m(1 ft.), 0.6 m (2 ft.), and 1.6 m (5.25 ft.) Sea Level Rise Projections (Univ. of FL 2015)

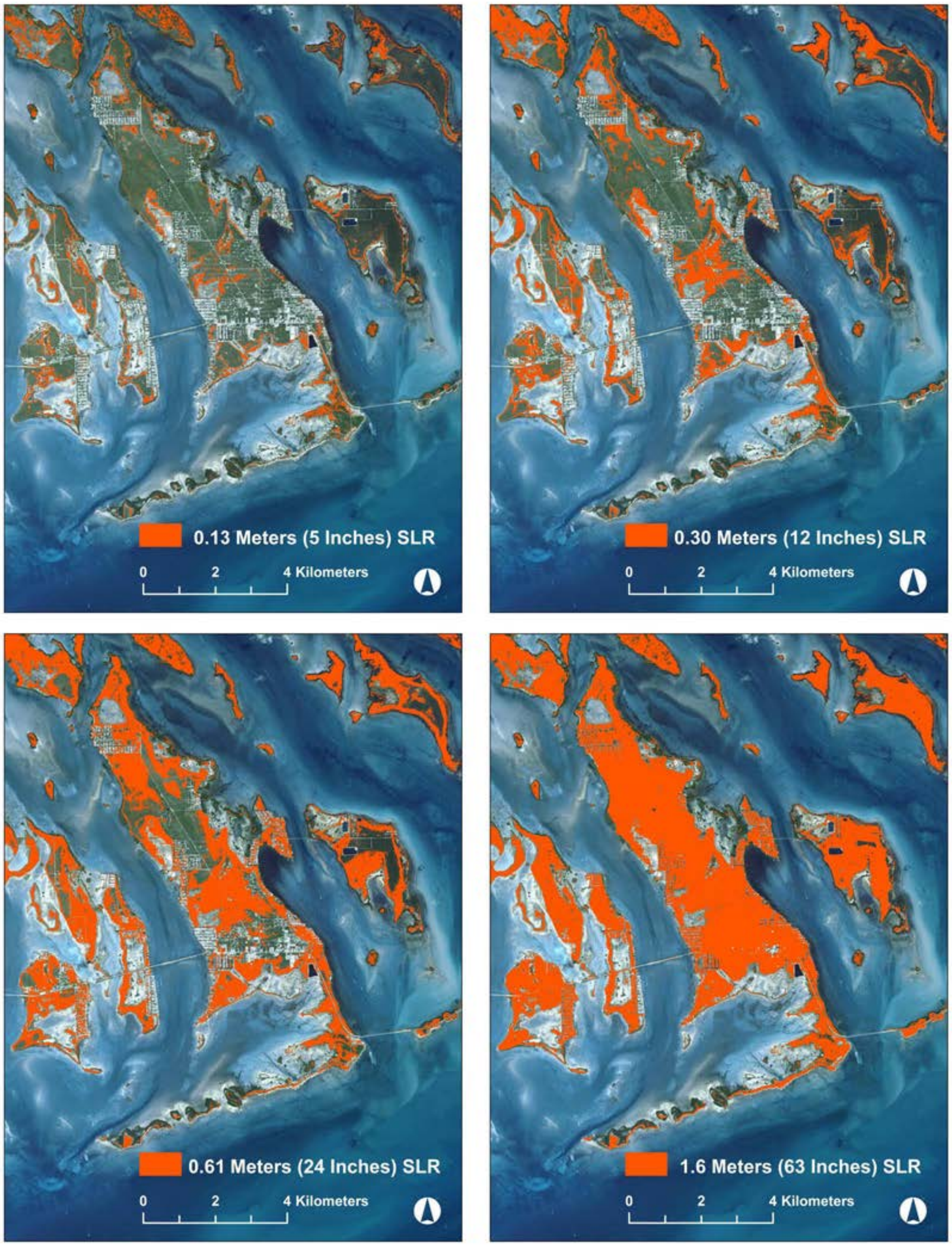


Figure 5-7. Big Pine Key 0.13 m (5 in), 0.3 m(1 ft.), 0.6 m (2 ft.), and 1.6 m (5.25 ft.) Sea Level Rise Projections (Univ. of FL 2015)

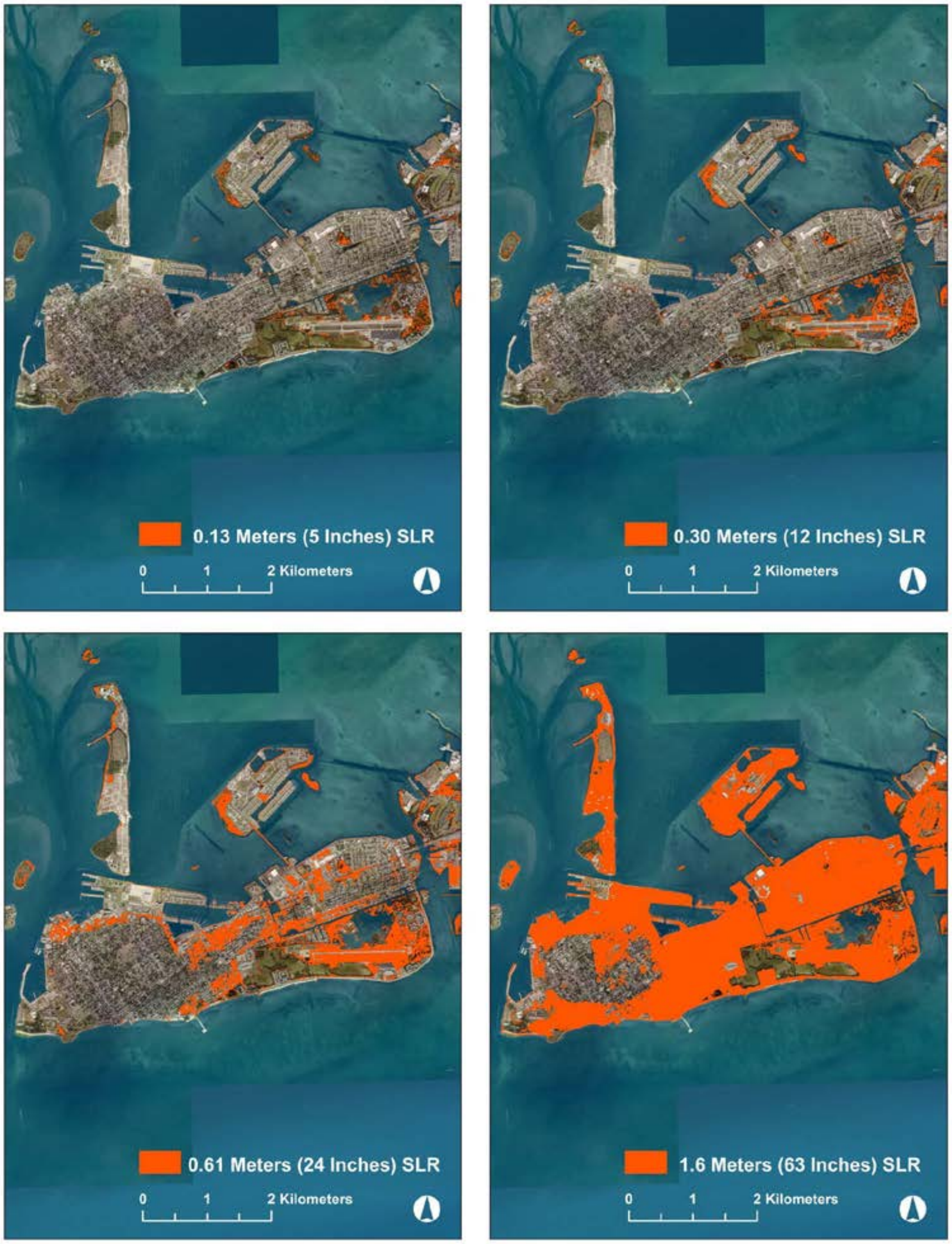


Figure 5-8. Key West 0.13 m (5 in), 0.3 m(1 ft.), 0.6 m (2 ft.), and 1.6 m (5.25 ft.) Sea Level Rise Projections (Univ. of FL 2015)

Sandy, dry unconsolidated soils are used by FL Keys mole skink for cover, movement, and nesting. There are only approximately 155.4 ha (384 ac) of quantified sandy soils (identified as Beach sand and Bahia fine sand) in the Keys in Monroe County (Table 2-1; Table 2-2). The soils mainly occur on six of the major Keys across twenty locations ranging in size from 1.61 ha (3.98 ac) to 28.95 ha (71.54 ac), and at an average size of approximately 7.7 ha (19.2 ac)(Table 2-2). There are small patches of sandy soils that occur intermixed within other habitats across the islands, primarily in the coastal hammock. The quality, quantity, and sizes of these areas are not quantified but are expected to be utilized opportunistically by individual Florida Keys mole skink. Long Key has the largest amount of mapped sandy soils with a total of 47.6 ha (117.5 ac).

Approximately 20 percent of the total sandy soils are projected to be inundated at 0.13 m (5 in) of SLR; the projected 2040 Low curve. Approximately 50 percent of the sandy soils are projected to be inundated at 0.71 m (28 in; 2.3 ft.) (2060 High); and 84 percent at 1.6 m (63 in; 5.25 ft.)(2100 High)(Table 5-5).

Zhang et al. 2011 (pp. 15-16) used SLR projections based on digital elevation models (DEM) to project impacts to land area of the Keys. The DEM provided projections on land, population, and property inundation in 0.15 m increments. At a 0.6m (23 inches) or approximately 2 ft., Zhang et al. (2011, p. 12-13) projected SLR would inundate approximately 70 percent of total land surface, 17 percent of the current population, and 12 percent of the existing property of the FL Keys. For comparison, the 2040 projection under the High or worst case scenario curve (using the regional Univ. of FL SLR models) is equivalent to 0.38 m (15 inches), and under the high (worst case) curve, the 2060 projection is 0.71 m (28 in). The populations and property are established on the higher grounds of the mainland Keys. A 1.5 m (5 feet) rise (2100 projection under the high or worst case scenario) indicates 91 percent of land surface inundated; 71 percent of population centers and 68 percent of property in the Keys.

The Compact stated, "Substantial increase in SLR within the century is likely and may occur in rapid pulses rather than gradually."(Compact 2015, p.13). SLR inundation curves show a non-linear behavior with a tipping point at approximately the 0.4 m (15.7 in) inundation level (Zhang 2011, p. 18). This is equivalent to the a) 2040 inundation in the high or worst case scenario or b) 2060 inundation level on the medium or moderate case scenario (Tables 5-4 and 5-5). Prior to these tipping points "direct and dramatic evidence" of SLR may not be evident but beyond which the rates of inundation accelerate rapidly (Zhang 2011, pp.14-15, 18).

As discussed, an accelerated rate of SLR is currently being documented, particularly for the eastern Atlantic Ocean coast, which anticipates the possibility that the tipping point will be reached sooner than first predicted (Zhang et al., 2011, pp.14-15; NOAA 2017b, p 14; Park and Sweet, 2015, entire article). The regional projected inundations for south Florida do not currently account for the expected accelerated rate of SLR. Because of the accelerated rates of SLR currently being documented and the confidence in the inundation curves indicating an abrupt tipping point, it is valuable to look at the effects of specific levels of inundation on the landscape rather than a specific year. Abrupt increases in inundation and projected losses of habitat occur around the 0.3 m (1 ft.) SLR (Table 5-4). This may occur as early as 2040 if the trend of the High SLR projection is followed. With a 0.3m (1ft) rise in sea level, approximately ten to 17 percent of suitable habitat and approximately 32 to 37 percent of all mole skink suitable soils in the Keys is projected to be inundated (Table 5-5; Figures 5-5, 5-6, 5-7, and 5-8).

Overall, the land area of the Lower Keys is shown to be more susceptible to SLR inundation than the Upper Keys (Zhang et al. 2011, p. 15). That is, in general, the Lower Keys are anticipated to experience the effects of SLR before the Upper Keys. However, local elevation and topography also influence the vulnerability to SLR. Big Pine Key in the Middle Keys is currently more vulnerable at the earlier stage of the SLR scenario than Key West in the Lower Keys, which is located at a higher elevation (Figures 5-5, 5-6, 5-7, and 5-8). This inundation of Big Pine is occurring early and gradually, prior to the tipping point being met when higher and accelerated SLR is then projected (Zhang et al. p. 16). This is reflective of the calculated land lost in Big Pine where 53 percent is projected to be inundated with an approximate two ft. of SLR (2060 at the high or worst case scenario) while just 36 percent of the total land of the Keys is projected to be lost at 2 ft. of SLR (Table 5-5).

A SLR of 2.5 meters (6.6 ft.) is a feasible projection based on the observed current trend of SLR and releases of GHG emissions (NOAA 2017a; NOAA 2017b, p.14). While there is only an approximately 0.05 to 1.0 percent probability that this will occur by 2100, the consequences to this level of inundation would be disastrous for the Keys' land mass and therefore must also be considered (cannot be overlooked) in future scenarios. The Compact (2012, p.1) projected SLR to be 0.15 to 0.25 m (6 to 10 in) by 2030 (above the 1992 mean sea level). The increases are projected to be as high as 31 to 61 in by 2100 based on the unified modeling. The Compact (2012, p. 1) recommended that critical infrastructures with "design lives" in excess of 50 years to use the upper curves (worst case scenario) for planning values. Applying such protective measures is the challenge in Keys with limited land availability for set-backs and landward moves off of current shorelines.

The SLR projections predict inundation only and do not model the complex set of shifts that are anticipated to be triggered over time as the effects of SLR are experienced. Vegetation is expected to convert more towards tidal and salt-tolerant species with fewer hammock and buttonwood species. Human relocation "upland" and inward is projected as everything living is pushed by a rising sea and its impacts to higher and drier grounds.

To provide perspective on the impacts of SLR on the four genetically- identified populations on Boot Key, Bahia Honda, Big Pine, and Boca Chica, the land area and percentage of area lost at each of these Keys under each of the scenarios are provided in Appendix F. Big Pine Key, the largest of the four Keys, is projected to lose at least 67 percent of its land mass at 1.6 meters (5.3 ft.) of inundation (Figure 5-7). Approximately 53 percent of the Key is projected to be inundated with a SLR of 0.3 m (2.3 feet). Boot Key, a small uninhabited island, is projected to lose 50 percent of its land with just 0.2 m (8 inches) of SLR (the projected 2040 low curve or best case scenario). Bahia Honda, in the Lower Keys, persists relatively well with just 35 percent of it land projected to be lost with a 1.6m (5.3 ft.) SLR. Slight differences in elevation and topography (low lying areas and channels causing water access to inland areas) are two factors which account for these differences in inundation. SLR does not necessarily produce only shoreline inundation, particularly in the islands surrounded by water. Approximately 50 percent of Boca Chica in the Lower Keys is projected to remain with 1.6 meters (5.3 ft.) of inundation;

however, the remaining land is developed upland, primarily consisting of a military airport (shown with Key West in Figure 5-8). Models of SLR inundations generally indicate that the higher elevations of land in the Keys that persist longer also consist of the developed cities and communities including Key West, Marathon, and Key Largo.

5.3.1 Recorded Skink Observations and Inundations

The expected inundations of the historic and current skink data points under the various SLR projections were reviewed, and the results of this exercise need to be interpreted with caution. There are inherent inaccuracies using preliminary raw data, which includes some unverified GIS data and consists of only a few samples up to this point. The historic documentations do not have GIS data associated with them, and therefore, there is a low level of accuracy between the skink data points and the impacts of SLR. The GIS inundation layers, county base map, and the skink data points are not image-rectified with one another, so inaccuracies in the GPS coordinates can occur between the multiple layers. Because of these factors, and possibly also due to some sampling errors, a few of the GIS skink data points appear just offshore. Making assumptions or drawing conclusions from these results should be limited, and it is recommended to repeat this exercise once further data points are available and GPS coordinates are rectified between all data layer.

There are a total of 142 data points, 17 historic and 125 current, considered in the inundation scenarios (Figure 2-2). The inundation maps did not extend to the remote Keys of the Marquesas and the Dry Tortugas, so two skink data points were not included in this review. Inundation of individual data points (losses) increased exponentially at approximately two feet of SLR (equivalent to 2060 on the high curve or worst case scenario and 2100 on the medium curve or moderate case scenario). Losses of both historical and current data points on the low curve (best case scenario) ranged from 1 to 4 percent and increased to an 8 to 77 percent loss on the high (worst case) projected curve. In looking at just the current data, losses of points showed similar trends with a 0 to 3 percent loss on the low curve but losses from 8 to 83 percent by 2100 on the high (worst case scenario) projected curve. Prior to the exponential increase of inundation of data points, some of the data points on Key Largo, Big Pine, and Saddlebunch Key were lost in 2040 under the low inundation projection (best case scenario). Approximately 20 percent of Big Pine current individual counts persist across all scenarios, and this may be attributed to the higher sample size on that Key. A few historical data points also remain even at the worst case scenario (but these locations do not have GPS records). This information suggests that some individuals may persist even in the worst case scenario, both interiorly and along the beach berm, but overall the skink data points exhibit high loss (70 percent or higher) at this level of inundation. Inland as well as coastal data points experience inundation which supports the understanding that SLR does not just occur along a shoreline.

Increased SLR and inundation may increase the incidence of possible random dispersal from rafting and assist in survivability of some skinks when their habitat becomes inundated. However, the effectiveness (ability to reach other islands from rafting) of this dispersal would ultimately be expected to worsen with inundation as land mass decreases and the distance between land increases.

5.3.2 Level of Certainty or Uncertainty

As mentioned earlier, there is a high level of certainty in exceeding the low projections (near 100%). Under the global likelihoods of SLR, IPCC (2013, p.7) states the "increased incidence and/or magnitude of extreme high sea level" is very likely. Heavy precipitation events are "very likely" over mid-latitude and wet tropical regions. Warmer days and nights and over most land and fewer cold days and more frequent hot days are "Virtually Certain"(IPCC (2013, p.7). The increase in the frequency and duration of warm spells/heat waves over most land areas is "very likely" (IPCC (2013, p.7).

5.3.3 Key Considerations of Future Condition

a) Lag time on SLR - It is not possible to reverse what trend is already underway based on the levels of GHG emissions already released into the atmosphere (Deconto and Pollard, 2016, entire). This is why there is a high certainty in the exceedance of the low curve (NOAA 2017, p.33; Compact 2012, p. 5).
b) An accelerated rate of SLR is being observed and is expected to increase. This is why NOAA increased the low and high expected ranges (NOAA 2017b, entire).
c) Tipping points in inundation are expected and have been predicted to occur around 2035-2060 with scenarios from 1.8 m to 0.6m (Zhang et al. 2011, p. 15). Increases in SL are occurring gradually and then the projected curves steepen which indicates that the inundation rate experiences an abrupt increase.

Table 5-7. FL Keys mole skink population resilience, subspecies redundancy, and subspecies representation under future scenarios

Population Resilience	**Subspecies Redundancy**	**Subspecies Representation**
Reduced resiliency expected to occur across all future scenarios. The level of reduced resiliency becomes a matter of scale in timing and intensity of SLR. Reduction or loss of suitable habitat and dry soils are main reason for reduced skink abundance and population resiliency under future scenarios. Abundance numbers are low; expected to remain low or become reduced.	Reduced redundancy expected with all scenarios. Generally expect loss of habitat and inundation impacting areas in the Lower Keys prior to the Upper Keys. No current observations or captures of skinks in the Upper Keys. Generally, larger islands retain habitat longer than smaller ones. Not at all times the case: Big Pine Key is a larger island in Middle Keys that inundates earlier and to a greater extent than some of the smaller islands in that area.	Current condition of low genetic and environmental diversity. Little breadth to rely on if some lost. Not a large difference in habitat types and elevation. No significant "movement to higher ground." Any inland movement or movement to drier/higher areas is temporary. Islands of the Keys are surrounded by water so inundation can occur along all locations (not just along a coast). Higher grounds are where the cities and communities are located: Key West, Marathon, Key Largo.

High variations between islands exist in the projected inundation levels and timing of inundations to beach habitat and lower elevations. When ground cover is washed out, the insect abundance may decrease. When ground cover is washed out, the ability for skink to find cover, nest, and forage is reduced or compromised. The extent and duration of this impact is based on increases to flooding and storm surge and the rate of SLR.	A level of redundancy is retained because of the existence of the protected and conversation lands across the range. Although these habitats will be impacted by loss due to inundations. Shifts in vegetation from drier hammock and beach to tidal vegetation will be expected to reduce the quality and quantity of suitable habitat as SLR continues. Greater storm surge – overwash – is expected to reduce redundancy. Increased occurrence of storm surge and floods with increasing inundations is expected to reduce redundancy as occupied areas become flooded. There will be a decrease in recovery time for habitat and populations from the impacts of hurricanes and strong storms as storm intensity and occurrence of storms increases as predicted. Expect loss of populations and further loss of connectivity. Decreased ability to reach new island if are passively rafting.	Low genetics does not assist in sustainability. If a stressor impacts one, it will likely affect all. Stochastic events: For example drought or long term decrease in precipitation levels causes loss of tropical hammock and/or insect food source. This is likely to be a loss experienced across the range of the Keys. All skinks are susceptible.

5.4 Summary: Resilience, Representation, and Redundancy Under Future Scenarios

The subspecies future condition is most influenced by the unmanaged and persistent upward trend in SLR. The observed trend in SLR is currently meeting the high SLR curve projected in the 2009 models, and the rate of SLR is also now found to be accelerating (NOAA 2017b, p. 25; Carter et al. 2014, pp. 401-403; Park and Sweet 2015, entire). At this time, any global management actions currently in place towards the control of GHG emissions will not curb or reverse the ongoing trend. Even if stringent and immediate reductions in GHG emissions were underway, there is still a lag in response such that there is 100 percent chance of exceeding the SLR projected under the current “Low” (best case) scenarios (NOAA 2017b, p. 33).

Given the subspecies’ current condition (3Rs) and the impacts that the subspecies is expected to experience under the future scenarios, reductions in population resiliency, subspecies redundancy, and subspecies representation are expected. Even under the best case scenario, which includes the low curve of SLR and a reduction in population and development pressure on the Keys, adverse impacts in the form of patchily-distributed habitat or the loss of suitable habitat and soil losses are expected. A further lack of connectivity and dispersal capabilities of individuals between the islands is expected. These impacts are based on projected inundation of the land. It is extremely likely that impacts in the form of storm surges and flooding events (saltwater intrusion) will be taking place prior to the loss of the land from SLR.

Approximately 20 percent of the suitable sandy soils are projected to be inundated with 0.13m (5 in) of SLR (the 2040 Low SLR curve and best case scenario). As well, the land mass reduction across the range would create reduced availability of land mass (smaller islands). Loss of land would precipitate an increase in resource competition with people and other animals. Abundance numbers are likely to decrease according to the severity of inundation and loss of habitat and soils. Even in the low SLR curve (best case scenario), a loss of about 10 percent of the suitable habitat and 32 percent of the unconsolidated soils for the FL Keys mole skink are projected to be loss to inundation. This scenario is imminent according to the projections, current trend and lack of intervening management actions (NOAA 2017b, p. 21).

Habitat loss occurs exponentially across the Low, Medium and High SLR scenarios. At 0.13 m (5 in) of SLR, approximately two percent of coastal hammock and beach berm habitat can be expected to be inundated (and thirteen percent of all of the Keys land mass). By 0.3 m (1 ft.) of inundation, 11 percent of the skinks' suitable habitat (and 24 percent of all of the Keys land) is projected to be inundated. A 0.63 m (2 ft.) inundation (2060 High SLR and worst case scenario) impacts 44 percent of the suitable mole skink habitat (37 percent of all of the Keys land). Even if the population and development pressure decreases as land mass decreases (best case scenario), SLR will still produce loss of habitat and soils for the skink. This loss and consequent fragmentation of habitat is expected to decrease population size (Dubey and Shine 2010, p. 886). As mentioned, the worse-case scenario has an approximately 0.5 to 1.0 percent chance of being exceeded by 2100 according to the present models (NOAA 2017b, p. 21). This low occurrence probability is based on the uncertainty of what will occur in the future as SLR is projected to reach a tipping point and rapidly accelerate.

The probabilities of the moderate and worst case scenario occurring are lower compared to the best case scenario. There is a 50 percent chance the moderate scenario and a 0.05 to 0.1 percent chance the worst case scenario will be exceeded by 2100. The probabilities may be low, but the consequences for the FL Keys mole skink are high under these scenarios. Most importantly, while the scenarios appear to only gradually (over many years) impose impacts to the FL Keys mole skink, an abrupt acceleration in SLR are expected. Most importantly, no mechanisms are currently in place, globally or regionally, which indicate an aggressive or immediate reduction in global GHG emissions. Regardless of the time frames used in the modeled projections, SLR and other climactic changes will continue to progress and further impact the FL Keys mole skink until interventions are in place to minimize or reverse these stressors.

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APPENDICES

Appendix A. Opportunistic searches for FL Keys mole skinks from November 2016 through January 2017.

Location	**Hours Searched**	**Mole skink Located? Y/N***	**Number of searchers**
Lower Sugarloaf	1	N	one
Long Key State Park	4	**Y***	two
Long Key State Park	3	N	one
Marquesas/Long Key	5	N	two
Marquesas/Long Key	6	N	two
Marquesas/Long Key	6	N	two
Content Key	4.5	**Y (3 skinks)**	three
Snipe Point	2.5	N	three
Snipe Point	2	N	two
Marquesas/Main/Third/Short	6	N	one
Cook Island	1.5	N	one
Cook Island	1.5	**Y**	two
Big Munson Key	4	N	two
Big Munson Key	4	**Y(3 skinks)**	two
Curry Hammock State Park (Marathon)	3	N	two
Scout Key	6	N	three
Scout Key	3	N	two
Totals:			
17 searches; 10 locations	63 hours	8 skinks; 4 locations	Average two observers

*Y = 1 skink observed unless otherwise noted.

Appendix B. Technical Team Working Group Members.

Alphabetical Order:

Layne Bolen – USFWS biologist; Florida Keys mole skink Team Lead
Billy Brooks – USFWS biologist; Cedar Key mole skink Team Lead
Shana DiPalma – USFWS biologist; cartographer
Adam Emerick – USFWS biologist; Florida Keys Refuge Complex
Kevin Enge – Herpetological expert; Florida Fish and Wildlife Conservation Commission
Andrew Gude – USFWS Cedar Key National Wildlife Refuge Manager
Jonathan Mays – Herpetological expert; Florida Fish and Wildlife Conservation Commission
Katie Mercier – Master's graduate student; University of Central Florida, Department of Biology
Lori Miller – USFWS biologist; meteorologist; climate change specialist
Paul Moler – Herpetological expert; mole skink species expert; Retired Florida Fish and Wildlife Conservation Commission
Dr. Henry Mushinsky – Herpetological expert; mole skink species expert; Retired University of South Florida
Lindsay Nester – USFWS biologist
Dr. Christopher Parkinson – Professor; University of Central Florida, Department of Biology

Florida Keys and Cedar Key Mole Skinks Life History Needs and Current Conditions Technical Team Workshop held on December 8, 2016.

Appendix C. Current Condition Exposure Table

Activity	Exposure		Biology			Consequences				
						Individuals		Populations	Species	A/M/M
Terminal Activity	DIRECT Interaction	INDIRECT Interaction	Resources or Individuals Exposed	Life Stage Affected	Resource Functions	Responses to Exposure	Effects	Effects to Reproduction, Numbers, Distribution	Representation Resiliency Redundancy	
Dumping	crushing	shade, loss of habitat, alterations predator/prey	ind. skinks,	all	shelter	trauma, dispersal	death, E expenditure	decline in #'s	decline in viability	
Armoring	crushing	erosion of beach habitat	ind. skinks, sandy beaches	all	shelter	trauma, dispersal	death, E expenditure	decline in #'s	decline in viability	
Development (Commercial/ Residential)	crushing	permanent habitat loss, alterations predator/prey	ind. skinks, habitat	all	shelter	trauma, dispersal	death, E expenditure	decline in #'s	decline in viability	
ATVs or other ORVs	crushing	decline in habitat suitability, alterations predator/prey	ind. skinks, habitat	all	shelter	trauma, dispersal	death, E expenditure	decline in #'s	decline in viability	
Beach Raking	raking	decline in habitat suitability, alterations predator/prey	ind. skinks, habitat	all	shelter	trauma, dispersal	death, E expenditure	decline in repro. and #'s	decline in viability	
Few, Small, Isolated Pops			ind. skinks	adults		decline in repro.		decline in repro. and distribution	decline in viability	
Dispersal										
Fire Ants	depredation		habitat	eggs?		trauma	death	decline in repro.	decline in viability	
Invasive Vegetation	habitat loss		habitat	all	shelter	dispersal	E expenditure	decline in distribution	decline in viability	
Snakes										

Appendix C. continued.

Extreme Weather Events	inundation of habitat, death	decline in habitat suitability, predator/prey/ disease transitions, vegetation shifts	ind. skinks, habitat	all	shelter	sex ratios, thermoregul ation, trauma	skewed sex ratios, death	decline in repro and #'s	decline in viability	
Oil Spills	oiling	decline in habitat suitability, alterations predator/prey, loss of habitat	ind. skinks	all	shelter	trauma	death	decline in repro, #'s, and distribution	decline in viability	
Disease/Pred ators/Parasite s	death		ind. skinks	all		disease, infection, trauma	death	decline in repro, #'s, and distribution	decline in viability	
Climate Change/SLR	inundation of habitat	Changes in temp., rainfall, storm frequency/sev erity, vegetation shifts, salinization of soils, soil type transitions, habitat loss	ind. skinks, habitat	all	shelter	trauma, dispersal	death, E expenditure	decline in repro, #'s, and distribution	decline in viability	
Temperature Change		predator/prey/ disease transitions,	ind. skinks, sand	all	shelter	sex ratios, thermoregul ation	skewed sex ratios	decline in repro and #'s	decline in viability	

Appendix C. continued.

Change in Rainfall Patterns		vegetation shifts	ind. skinks, sand	all	shelter	sex rations, thermoregulation	skewed sex ratios	decline in repro and #'s	decline in viability	
Storm frequency/severity	inundation of habitat	decline in habitat suitability, alterations predator/prey, loss of habitat, vegetation shifts	ind. skinks and habitat	all	shelter	trauma, dispersal	death, loss of habitat	decline in repro., #'s, and distribution	decline in viability	
Collection	death	reduction in pop. #'s	ind. skinks	adults, eggs?		death	death	decline in repro., #'s, and distribution	decline in viability	
Pesticides	reduced fitness, death	reduction in prey availability, 2ndary exposure thru prey	ind. Skinks	adults, eggs?	shelter	trauma, loss of prey availability	death, E expenditure	decline in repro., #'s, and distribution	decline in viability	

Appendix D. Global and regional sea level rise projections used for future scenario assessment.

NOAA 2017b						
	Low	Intermediate-low	Intermediate	Intermediate-high	High	Extreme
2020	0.06 m (0.2 ft.)	0.08 m (0.26 ft.)	0.1 m (0.33 ft.)	0.1 m (0.33 ft.)	0.11 m (0.36 ft.)	0.11 m (0.36 ft.)
2030	0.09 m (0.3 ft.)	0.13 m (0.43 ft.)	0.16 m (0.52 ft.)	0.19 m (0.62 ft.)	0.21 m (0.69 ft.	0.24 m (0.79 ft.)
2040	0.13 m (.43 ft.)	0.18 m (0.59 ft.)	0.25 m (0.82 ft.)	0.3 m (0.98 ft.)	0.36 m (1.18 ft.)	0.41 m (1.35 ft.)
2050	0.16 m (0.52 ft.)	0.24 m (0.79 ft.)	0.34 m (1.12 ft.)	0.44 m (1.44 ft.)	0.54 m (1.77 ft.)	0.63 m (2.07 ft.)
2060	0.19 m (0.62 ft.)	0.29 m (0.95 m)	0.45 m (1.48 ft.)	0.6 m (1.97 ft.)	0.77 m (2.53 ft.)	0.9 m (0.3 ft.)
2070	0.22 m (0.72 ft.)	0.35 m (1.15 ft.)	0.57 m (1.87 ft.)	0.79 m (2.59 ft.)	1 m (3.28 ft.)	1.2 m (3.94 ft.)
2080	0.25 m (0.82 ft.)	0.4 m (1.31 ft.)	0.71 m (2.33 ft.)	1 m (3.28 ft.)	1.3 m (4.27 ft.)	1.6 m (5.25 ft.)
2090	0.28 m (0.91 ft.)	0.45 m (1.48 ft.)	0.85 m (2.79 ft.)	1.2 m (3.93 ft.)	1.7 m (5.58 ft.)	2 m (6.56 ft.)
2100	0.3 m (0.98 ft.)	0.5 m (1.6 ft.)	1 m (3.28 ft.)	1.5 m (1.92 ft.)	2 m (6.56 ft.)	2.5 m (8.20 ft.)

Parris et al. 2012				
	Low	Intermediate-low	Intermediate-high	High
2100	0.3 m (0.66 ft.)	0.6 m (1.64 ft.)	1.2 m (3.94 ft.)	2 m (6.56 ft.)

IPCC 2013 RCP – Representative Concentration Pathways (GHG concentrations)				
	Low (RCP2.6)	Intermediate-low (RCP4.5)	Intermediate-high (RCP6.0)	High (RCP8.5)
2046-2065	0.24 m (0.79 ft.)	0.26 m (0.85 ft.)	0.25 m (0.82 ft.)	0.3 m (0.98 ft.)
2081-2100	0.4 m (1.31 ft.)	0.47 m (1.54 ft.)	0.48 m (1.57 ft.)	0.63 m (2.067 ft.)

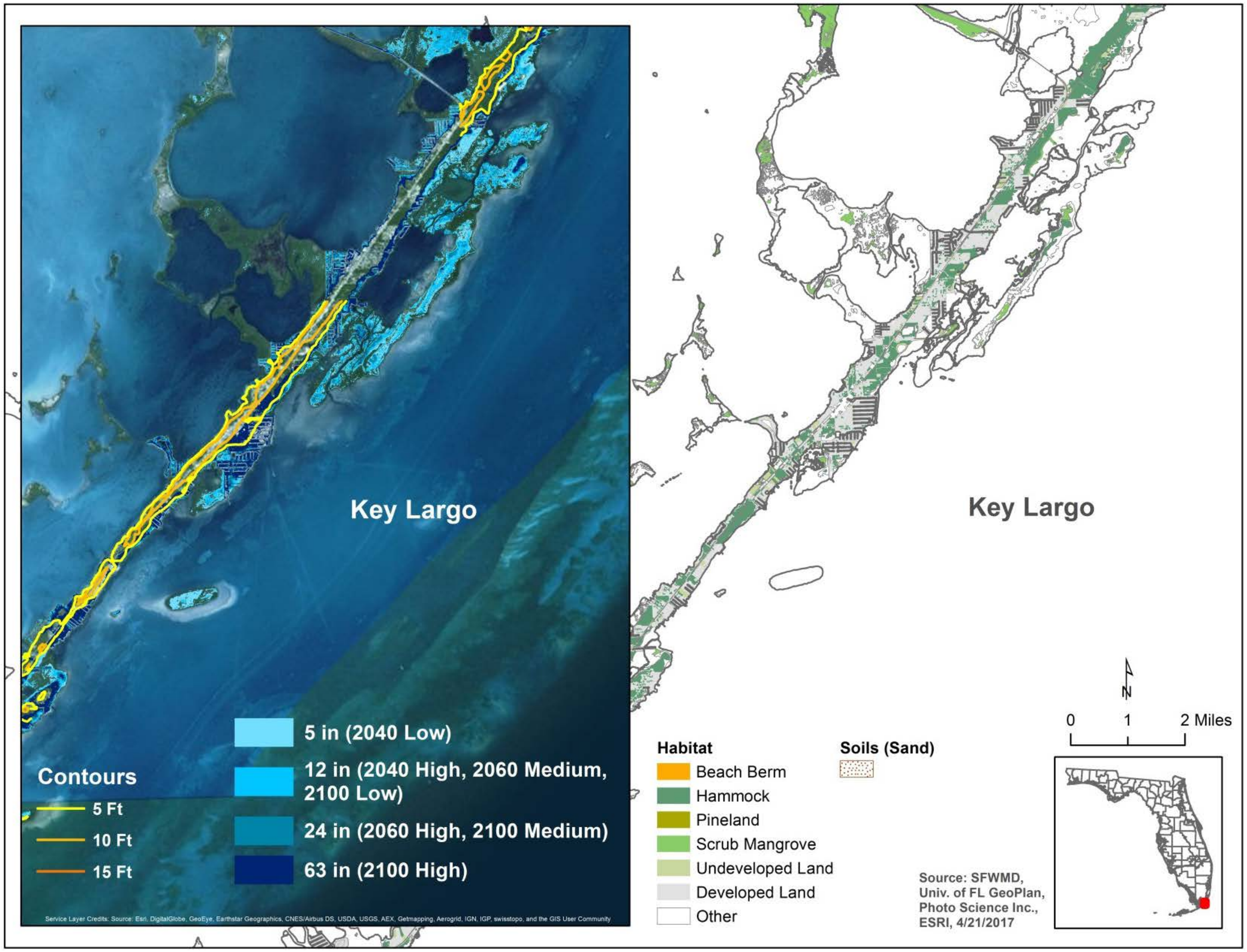
Univ. of FL Geoplan 2015 Estimated Relative South Florida Regional Sea Level Change Projections			
Year	Low meters (in) (ft.)	Medium meters (in) (ft.)	High meters (in) (ft.)
2020	0.1 (3.9)	0.1 (3.9)	0.2 (7.9)
2040	0.13 (5)	0.2 (8)	0.38 (15) (1.25 ft.)
2060	0.18 (7)	0.3 (12) (1 ft.)	0.71 (28) (2.3 ft.)
2100	0.28 (11)	0.61 (24) (2 ft.)	1.6 (63) (5.25 ft.)

Hall et a. 2016				
	Low	Intermediate-low	Intermediate-high	High
2100	0.4 m (1.31 ft.)	0.7 m (2.3 ft.)	1.3 m (4.27 ft.)	2.1 m (6.89 ft.)

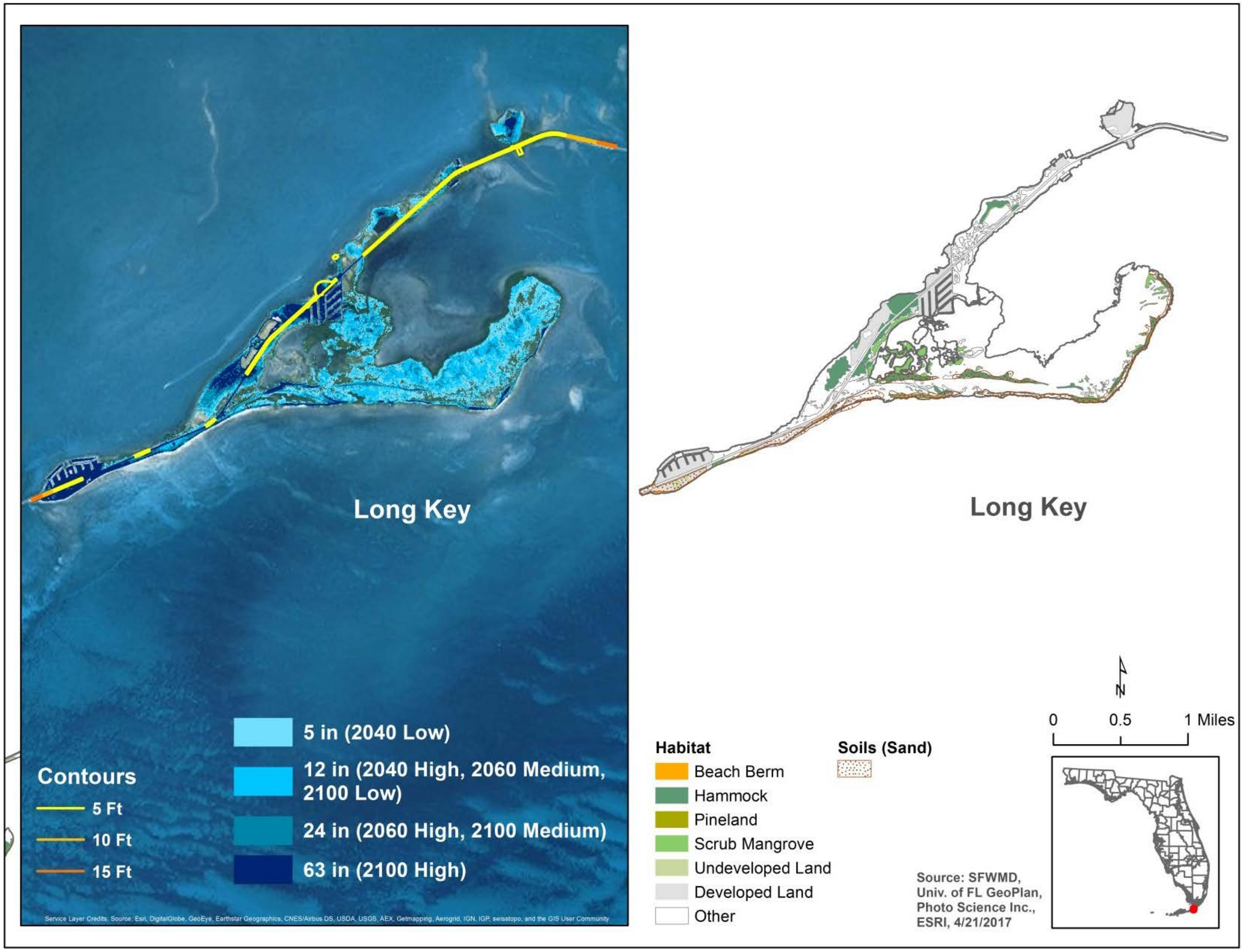
Compact 2015, p. 5			
	IPCC AR5 (median)	USACE High	NOAA High
2030	0.15 m (6 in)	0.25 m (10 in)	0.30m (12 in)
2060	0.36 m (14 in)	0.66 m (26 in)	0.86 m (34 in)
2100	0.79 (31in)	1.5 m (61 in)	2.1 m (81 in)

Appendix E. Best, moderate and worst case SLR projections from 2040 to 2100, and suitable FL Keys mole skink habitats and soils for Key Largo, Long Key, Big Pine, and Key West (Univ. of FL 2015; Monroe County 2016).

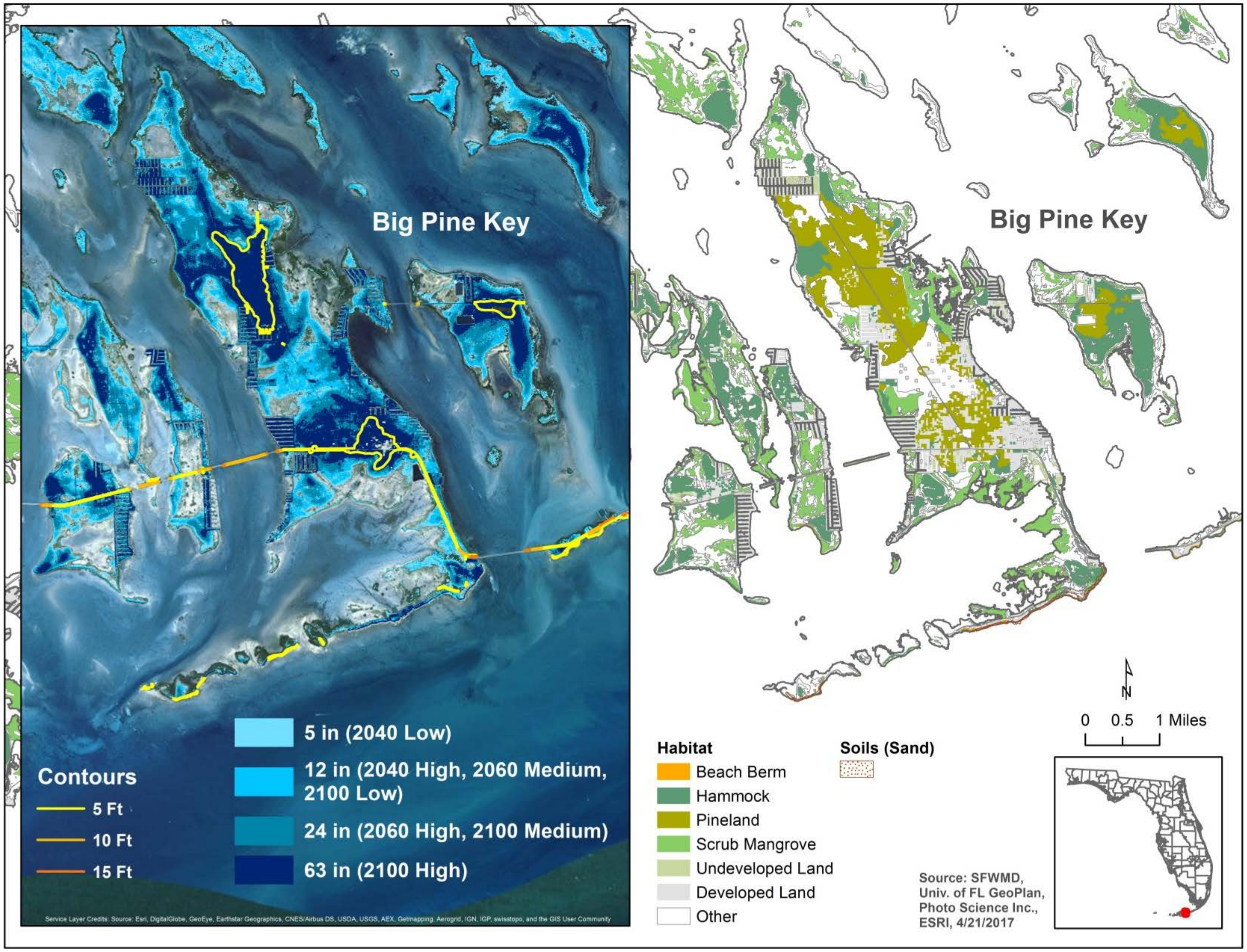
Predicted Sea Level Rise and Habitat Type for Key Largo



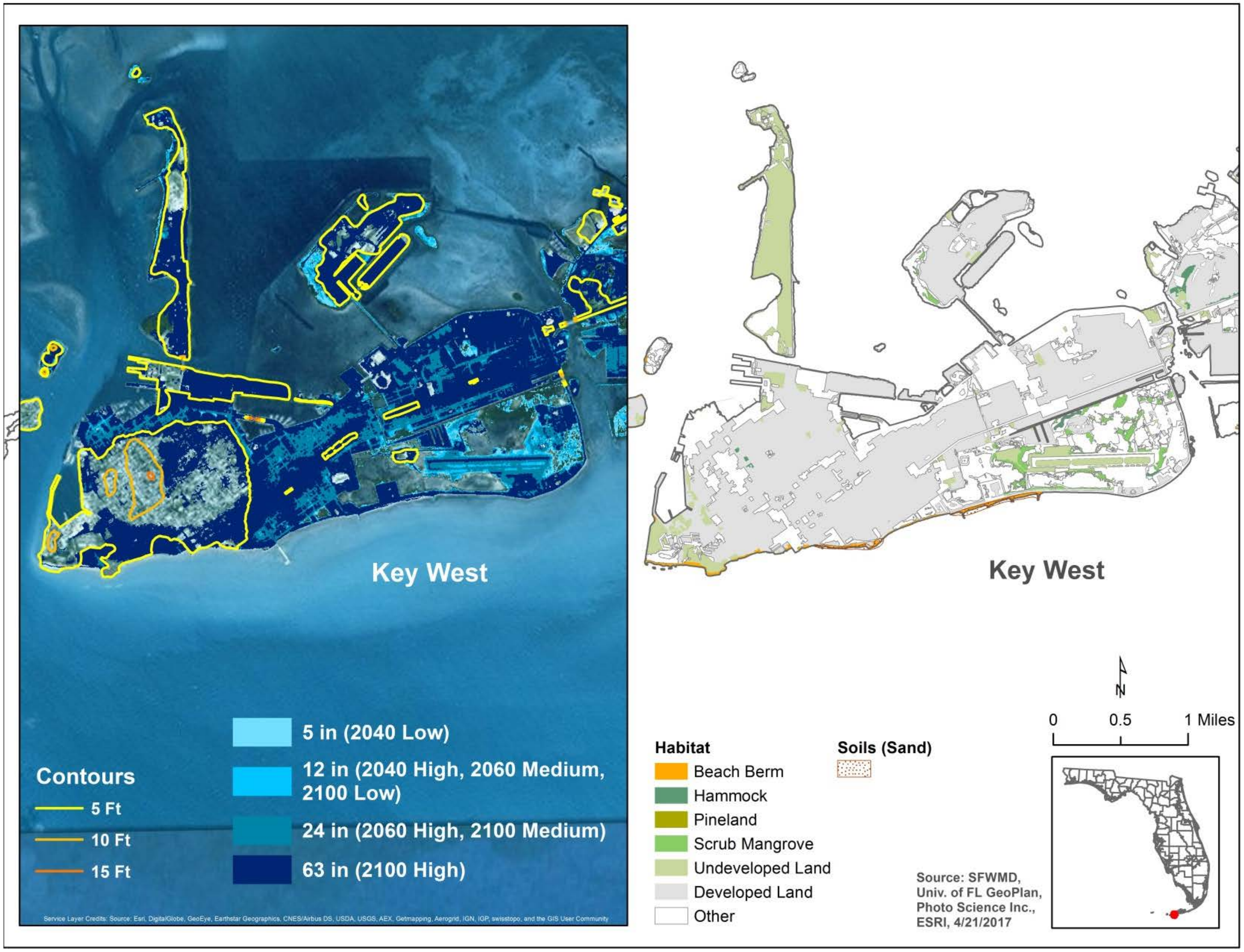
Predicted Sea Level Rise and Habitat Type for Long Key



Predicted Sea Level Rise and Habitat Type for Big Pine Key



Predicted Sea Level Rise and Habitat Type for Key West



Appendix F. Sea Level Rise projections for Boot, Bahia Honda, Big Pine, and Boca Chica Keys with identified FL Keys mole skink populations.

			Location			
			Boot Key	Bahia Honda	Big Pine Key	Boca Chica*
Current Area Hectare (Acres)		SLR m (in)(ft.)	257 (635)	203 (502)	2500 (6180)	2018 (4986)
Area Lost to Inundation Hectare (Acres)	2040L	0.13 (5)	93 (229)	19 (47)	261 (645)	182 (449)
	2040M	0.2 (8)	128 (317)	26 (64)	1416 (1029)	276 (683)
	2040H	0.38 (15) (1.25)	162 (401)	36 (88)	741 (1831)	458 (1132)
	2060L	0.18 (7)	121 (299)	24 (60)	378 (934)	253 (626)
	2060M	0.3 (12) (1)	153 (377)	32 (79)	600 (1483)	383 (947)
	2060H	0.71 (28) (2.3)	178 (441)	48 (119)	1320 (3261)	733 (1812)
	2100L	0.28 (11)	149 (369)	31 (76)	563 (1392)	363 (897)
	2100M	0.61 (24) (2)	175 (432)	44 (109)	1136 (2807)	650 (1607)
	2100H	1.6 (63)(5.25)	189 (466)	68 (169)	1892 (4675)	1063 (2626)
Area Remaining Under SLR Scenarios Hectare (Acres)	2040L	0.13 (5)	164 (406)	184 (455)	2240 (5535)	(1836) 4537
	2040M	0.2 (8)	129 (318)	177 (438)	2085 (5151)	1741 (4303)
	2040H	0.38 (15) (1.25)	95 (234)	168 (414)	1764 (4349)	1560 (3854)
	2060L	0.18 (7)	136 (336)	179 (442)	2123 (5246)	1764 (4360)
	2060M	0.3 (12) (1)	104 (258)	171 (423)	1901 (4697)	1635 (4039)
	2060H	0.71 (28) (2.3)	79 (194)	155 (383)	1181 (2919)	1284 (3174)
	2100L	0.28 (11)	108 (266)	172 (426)	1938 (4788)	1655 (4089)
	2100M	0.61 (24) (2)	82 (203)	159 (393)	1365 (3373)	1367 (3379)
	2100H	1.6 (63)(5.25)	68 (169)	135 (333)	609 (1505)	955 (2360)

Percent Loss Under SLR Scenarios	2040L	0.13 (5)	36	9	10	9
	2040M	0.2 (8)	50	13	17	14
	2040H	0.38 (15) (1.25)	63	18	30	23
	2060L	0.18 (7)	47	12	15	13
	2060M	0.3 (12) (1)	59	16	24	19
	2060H	0.71 (28) (2.3)	69	24	53	36
	2100L	0.28 (11)	58	15	23	18
	2100M	0.61 (24) (2)	68	22	45	32
	2100H	1.6 (63)(5.25)	73	34	76	53

*Includes Boca Chica, Geiger, Rockland, and East Rockland Keys.