REPTILES & AMPHIBIANS

Distribution and Ecology of the Cedar Keys Mole Skink (*Plestiodon egregius insularis*)

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Abstract.—We conducted surveys for the Cedar Keys Mole Skink, *Plestiodon egregius insularis* (Mount), during 1989–1999 and 2015–2024, examined museum vouchers, and compiled personal observations from others to determine the status and distribution of this subspecies, which has the smallest geographic distribution of the five subspecies and is being considered for federal listing. We observed Cedar Keys Mole Skinks on Airstrip Island, Atsena Otie, Cedar Point, Deer Island, North Key, Scale Key, Seahorse Key, Snake Key, and possibly Dog Island. We have anecdotal reports of Mole Skinks on Way Key, which contains the most potential habitat and is the main island occupied by the City of Cedar Key. We found Mole Skinks along shorelines in tidal wrack and under debris but seldom searched island interiors, which presumably shelter populations from storm surges that periodically scour beaches of refugia. This subspecies, which has been proposed for federal listing as endangered, is primarily threatened by habitat loss from rising sea levels and more frequent and intense storms resulting from climate change.

Four of five recognized subspecies of Mole Skink (*Plestiodon egregius*) are endemic to Florida (Mount 1968; Powell et al. 2016). The Cedar Keys Mole Skink (*P. e. insularis*), which has the smallest range of any of these subspecies, apparently is confined to islands in the Gulf of Mexico in the Cedar Keys area of Levy County, Florida (Enge 2019). The U.S. Fish and Wildlife Service (USFWS) (2018a) initially determined that it did not warrant federal listing but has since proposed listing it as endangered, primarily because of the threat posed by sea-level rise as a consequence of climate change (USFWS 2024).

Mount (1965) described the Cedar Keys subspecies based on specimens from Seahorse Key and the George T. Lewis Airport, which is on an unnamed island that is the type locality. Mount (1963) referred to it as "Airstrip Island," but it is not differentiated from Way Key on maps. No records of Mole Skinks exist for Rye Key, the third island that comprises the City of Cedar Key. Mount (1965) reported that adults of the Cedar Keys Mole Skink and western populations of the Northern Mole Skink (*P. e. similis*) are practically indistinguishable, with light dorsolateral stripes that neither widen nor diverge; however, the stripes on the Cedar Keys Mole Skink are more inconspicuous and fail to reach the tail on about half of specimens (Fig. 1). The primary characteristic that Mount (1965) provided to distinguish the Cedar Keys Mole Skink is uniformly dark neonates, but Enge et al. (2024) found that neonates are similar to those of most other subspecies and suspected that Mount described a rare melanistic phenotype. Mount (1965) found no evidence of intergradation between the Cedar Keys Mole Skink and mainland Mole Skinks, but he did not examine specimens from nearby scrub habitat on the mainland. Mitochondrial DNA analyses found that haplotype diversity is lowest for the Cedar Keys subspecies, which is most closely related to the Peninsula Mole Skink (*P. e. onocrepis*) (Branch et al. 2003). A study using genome-wide single nucleotide polymorphisms found that the Cedar Keys Mole Skink is monophyletic and has had little contact with mainland populations since the sea level rose after the last glacial maximum; each island has retained a genetically distinct population due to restricted gene flow (Mercier 2018).

Little information has been published regarding the natural history of the Cedar Keys Mole Skink. Mount (1963) found specimens at or above the spring tide mark under dry or slightly wet beach wrack or under small piles of dead grass on the George T. Lewis Airport runway. Mount (1963) reported a clutch of five eggs, and Scott et al. (2023) reported

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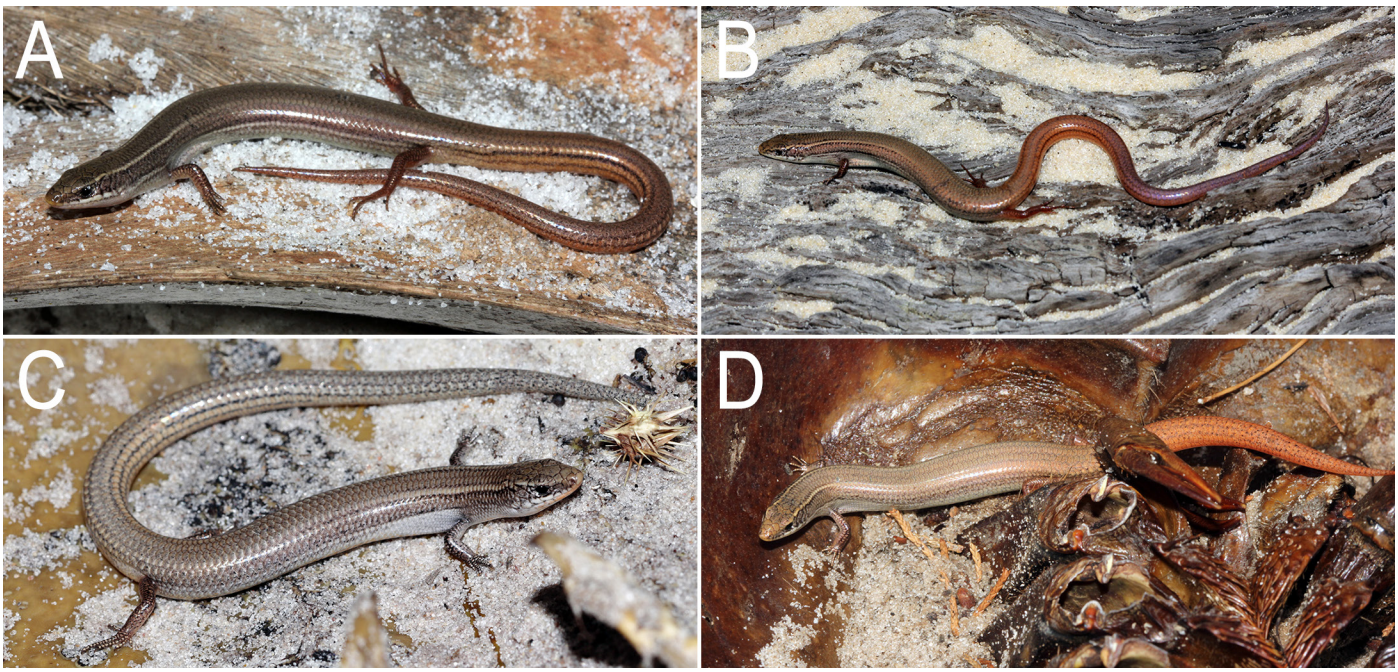

Figure 1. Adult Cedar Keys Mole Skinks (*Plestiodon egregius insularis*) from Atsena Otie (UF-Herp 193009) (A), Seahorse Key (UF-Herp 195213) (B), Deer Island (UF-Herp 193451) (C), and North Key (UF-Herp 195136) (D), Levy County, Florida. Photographs by Kevin Enge.

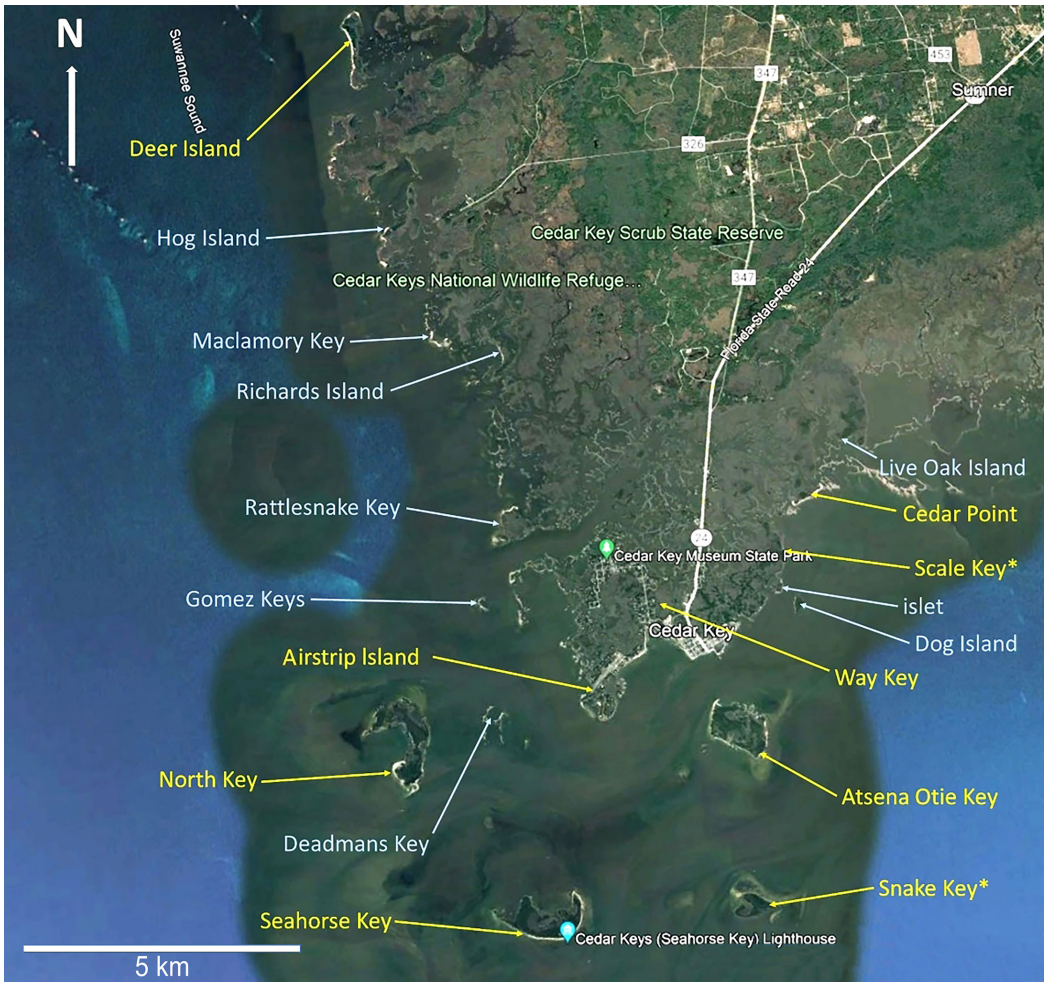

Figure 2. Google Earth© image showing islands in Levy County, Florida, with credible records of the Cedar Keys Mole Skink (*Plestiodon egregius insularis*) in yellow (asterisk indicates no records since 2004) and islands that were searched unsuccessfully in light blue.

on five more clutches, including a clutch of 13 eggs, the maximum reported for Mole Skinks. Amphipods, earwigs, beetle larvae, and small Fiddler Crabs (*Uca* sp.) are thought to be caught and eaten underground (Mount 1963).

Understanding the distribution of the Cedar Keys Mole Skink and whether populations are still extant on various islands were important in determining the status of its federal listing. Populations of this insular subspecies are apparently confined to nine islands (Fig. 2), making them vulnerable to sea-level rise, catastrophic storms, habitat loss or degradation, and invasive species (USFWS 2018b). If Cedar Keys Mole Skinks occur on additional islands or on the adjacent mainland, they might be more resilient to catastrophic events. We herein report distributional and natural history information from surveys conducted in 1989–1999 and 2015–2024 plus personal communications from other observers.

Methods

We compiled records of the Cedar Keys Mole Skink from museums, the Florida Natural Areas Inventory (FNAI) database, literature, and personal communications. We surveyed various islands during two time periods separated by at least 16 years. A team comprised of one to five University of Florida (UF) students surveyed for Mole Skinks on 20 trips from 5 March 1989 to 20 May 1999 (Table 1). The UF team surveyed one to five islands per trip for 15 min to 3.25 h per

Table 1. Numbers of Cedar Keys Mole Skinks (*Plestiodon egregius insularis*) collected or observed from 1951 through 2024 on various islands in Levy County, Florida, USA.

Island	Year	Collected (Observed)	Source
Airstrip Island	1951–59	16 (0)	UF-Herp 3125–26, 12583, 134005–15; TNC Herpetology 76678–79
Airstrip Island	1960–69	12 (0)	UF-Herp 12587, 12598, 12616, 12619, 12689, 86594–99; ABS 379
Airstrip Island	1960–69	0 (~80)	B. Mansell, pers. comm.; UF-Herp 195209 (photo)
Airstrip Island	1970–79	6 (0)	UF-Herp 57850–51; LACM 109412; ABS 380–82
Airstrip Island	1988	1 (0)	CAS 165939
Airstrip Island	Mar 1989 (4 trips)	4 (4)	This study, UF-Herp 166544 (photo)
Airstrip Island	Jan 1990	0 (1)	This study
Airstrip Island	Feb 1990	1 (1)	This study (JMM pers. research collection)
Airstrip Island	Mar 1990	7 (6)	This study (JMM pers. research collection), ROM 46978–79, 46982)
Airstrip Island	Apr 1990	3 (0)	This study; ROM 46980–81 (only 2 vouchered)
Airstrip Island	Dec 1990	1 (0)	This study (JMM pers. research collection)
Airstrip Island	Jul 1994	1 (0)	This study (JMM pers. research collection)
Airstrip Island	May 1999	0 (0)	This study
Airstrip Island	2008–14	2 (13)	J. Scott, pers. comm.; UF-Herp 195210 (photo)
Airstrip Island	Oct 1999	0 (0)	P. Moler & K. Enge
Airstrip Island	Apr 2022	0 (0)	This study
Airstrip Island	Sep 2023	0 (1)	N. Jenkins; UF-Herp 194121 (photo)
Atsena Otie	May 1990	4 (2)	This study (UF-Herp 194378–81))
Atsena Otie	Sep 1993	1 (0)	This study (JMM pers. research collection)
Atsena Otie	Jun 2015	0 (0)	This study
Atsena Otie	Apr 2016	0 (2)	This study; UF-Herp 193009, 195129 (photos)
Atsena Otie	Nov 2023	0 (1)	M. Haag, M. Geller, and B. Rogers; UF-Herp 194122 (photo)
Cedar Point	Jun 2015	0 (5)	This study; UF-Herp 193008, 195208 (photos)
Cedar Point	Apr 2022	0 (0)	This study
Cedar Point	Jan 2024	0 (0)	This study
Deadmans Key	Sep 1990	0 (0)	This study
Deer Island	1962	1 (0)	UF-Herp 14177
Deer Island	Jul 2004	0 (1)	P. Moler & M. Endries
Deer Island	Oct 2022	0 (3)	This study; UF-Herp 193451, 195130 (photos)
Dog Island	Sep 1990	0 (0)	This study
Dog Island	Sep 1993	0 (1?)	This study
Dog Island	Jun 2022	0 (0)	This study
Gomez Key	May 1994	0 (0)	This study
Hog Island	Oct 2022	0 (0)	This study

(Table 1 continued)

(Table 1 continued)

Live Oak Island	Jun 2022	0 (0)	This study
Mclamory Key	Oct 2022	0 (0)	This study
North Key	May 1990	0 (0)	This study
North Key	Jul 1990	10 (6)	This study; UF-Herp 193899–900, 193939 (photos) and JMM pers. research collection
North Key	Sep 1990	5 (0)	This study (JMM pers. research collection)
North Key	Feb 1993	2 (1)	This study (UF-Herp 194382–83)
North Key	May 1994	0 (0)	This study
North Key	2004	0 (1)	P. Moler & M. Endries
North Key	Mar 2015	0 (3)	This study; UF-Herp 195141 (photo)
North Key	Jun 2015	0 (12)	This study; UF-Herp 193007, UF-Herp 195136–39 (photos)
North Key	Dec 2016	0 (0)	This study
North Key	Apr 2022	0 (7)	This study; UF-Herp 195131–32, 195135 (photos)
North Key	Oct 2023	0 (0)	This study
North Key	Jan 2024	1 (0)	This study; UF-Herp 194117
Rattlesnake Island	May 1994	0 (0)	This study
Rattlesnake Island	Oct 2022	0 (0)	This study
Richards Island	Oct 2022	0 (0)	This study
Scale Key	Feb 1993	7 (0)	This study (UF-Herp 194386–92)
Scale Key	Sep 1993	5 (5)	This study (JMM pers. research collection)
Scale Key	May 1994	1 (1)	This study (JMM pers. research collection)
Scale Key	2004	0 (1?)	P. Moler & M. Endries
Scale Key	Apr 2022	0 (0)	This study
Scale Key	Jun 2022	0 (0)	This study
Scale Key	Jan 2024	0 (0)	This study
Seahorse Key	1960	5 (0)	UF-Herp 12610–12, 12615, 12617
Seahorse Key	1972	1 (0)	GMNH 3369
Seahorse Key	May 1990	2 (0)	This study (UF-Herp 194376–77)
Seahorse Key	2004	1 (0)	UF-Herp 141687
Seahorse Key	2014	0 (7)	UF-Herp 193012 (photo); M. Fedler, unpubl. data
Seahorse Key	Jul 2014	0 (1)	UF-Herp 202015 (photo)
Seahorse Key	Mar 2015	0 (3)	This study; UF-Herp 195142–43 (photos)
Seahorse Key	Jun 2015	0 (2)	This study; UF-Herp 195144 (photo)
Seahorse Key	Dec 2016	0 (1)	This study; UF-Herp 195213 (photo)
Seahorse Key	Apr 2022	0 (4)	This study; UF-Herp 195133–34, 195140 (photos)
Seahorse Key	Oct 2023	0 (0)	This study
Seahorse Key	Jan 2024	0 (0)	This study
Snake Key	May 1990	2 (0)	This study (JMM pers. research collection)
Snake Key	Feb 1993	2 (0)	This study (UF-Herp 194384–85)
Snake Key	2004	0 (1)	P. Moler & M. Endries
Snake Key	Dec 2016	0 (0)	This study
Snake Key	Oct 2023	0 (0)	This study
Way Key	Feb 1990	0 (0)	This study
Way Key	Mar 1997	0 (1)	R. Bartlett & K. Wray, pers. comm.
Way Key	2005	0 (1)	C. Trumbower, pers. comm.
Way Key	2006	0 (4)	K. Wray & P. Hill, pers. comm.
Way Key	2021	0 (2)	J. Post, pers. comm.
Way Key	Apr 2022	0 (0)	This study
Way Key	Apr 2023	0 (0)	This study
“Cedar Key”	1952	1 (0)	UF-Herp 7495
“Cedar Key (mainland)”	Jul 1971	1 (0)	UF-Herp 41252
“Cedar Keys”	1951, 1954	6 (0)	TNC Herpetology 76680–83; NCSM 08609–10
Ephemeral island N of Atsena Otie	May 1990	0 (0)	This study
Unnamed island S of Scale Key	May 1994	0 (0)	This study

Figure 3. Team of University of Florida students using potato rakes to uncover Cedar Keys Mole Skinks (*Plestiodon egregius insularis*) on Scale Key, Levy County, Florida, 25 September 1993. Photograph by Dennis Haney.

island by raking with potato rakes (3- or 4-pronged garden rakes) or searching by hand under and within tidal wrack and various types of debris, and digging in sand, broken shells, and among the roots of trees, bushes, and low-lying vegetation (Fig. 3). Most collected specimens were retained by one of us (JMM) for reproductive and dietary analyses. A second team comprised of one to eight people (primarily Florida Fish and Wildlife Conservation Commission [FWC] staff) surveyed for Mole Skinks on 10 trips from 10 March 2015 to 25 January 2024 (Table 1). The FWC team conducted more surficial and less intensive surveys of one to five islands per trip for 5 min to 2.0 h per island by raking by hand or with garden or potato rakes under tidal wrack, leaf litter, dead grass, driftwood, logs, and other debris. In addition, the second team twice surveyed scrub habitat, primarily in Cedar Key Scrub State Reserve, on the adjacent mainland. The amount of search time varied among islands and was primarily determined by the extent of preferred habitat and the presence of suitable debris. The FWC team collected only genetic samples (tail tips).

Results

During surveys in 1989–1999, we observed Cedar Keys Mole Skinks on Airstrip Island (N = 29), Atsena Otie (N = 7), North Key (N = 24), Scale Key (N = 19), Seahorse Key (N = 2), and Snake Key (N = 4) (Table 1). One skink observed by S.J. Walsh on Dog Island on 25 September 1993 was likely this species (Table 1), but its identity could not be verified before it escaped into densely rooted sedges and grasses. During surveys in 2015–2024, we observed Mole Skinks on Atsena Otie (N = 2), Cedar Point (N = 5), Deer Island (N = 3), North Key (N = 22), and Seahorse Key (N = 10) (Table 1). In addition, a Mole Skink was photographed on Airstrip Island and Atsena Otie in 2023 (Table 1). In 2015–2016, we collected a total of 25 genetic samples from Cedar Point, Atsena Otie, North Key, and Seahorse Key for a taxonomic assessment. We were the first to document Mole Skinks on Atsena Otie, Cedar Point, North Key, Scale Key, Snake Key, and possibly Dog Island. As of 2015, all museum records were thought to be from Airstrip Island or Seahorse Key, but we discovered that a specimen (UF-Herp 14177) was collected on Deer Island in 1962 according to its tag. The location given in the museum database was "Cedar Key, 5.0 mi N, SW Creek 347."

Researchers have collected at least 54 specimens from Airstrip Island. The end of the runway at the George T. Lewis Airport was the most well-known and accessible collection site, and six museum specimens from "Cedar Keys" in the 1950s likely came from there (Table 1). A museum specimen from "Cedar Key" and "Cedar Key (mainland)" (Table 1) probably came from Airstrip Island or Way Key,

Figure 4. Beach at the end of the runway at the George T. Lewis airport on the southwestern side of Airstrip Island, Levy County, Florida, in 1990 (left) and in 2022 after coastal armoring, which appears in the background (right). Photographs by Louis Somma (left) and Kevin Enge (right).

the main island occupied by the City of Cedar Key. The latter specimen (UF-Herp 41252) was mislabeled as a Little Brown Skink (*Scincella lateralis*). We failed to find Cedar Keys Mole Skinks on Way Key, where we primarily surveyed Cemetery Point Park and Cedar Key Museum State Park. We have credible reports of Mole Skinks observed on Way Key from scientists, recreational herpers, and residents. The most recent reports were from 2021 in yards near Cedar Key Museum State Park and on Sturgis Circle (Jesse Post, pers. comm.; Table 1). Mole Skinks were still being found at the airport until ca. 2013 (Table 1), when the entire perimeter was fenced for security reasons, restricting access. The end of the runway was subsequently armored (Fig. 4), eliminating most of the suitable habitat, although skinks have occasionally been found by raking oak leaves and clumps of dead grass along the northwestern side of the runway.

Islands with the most extensive suitable shoreline habitat are North Key, Seahorse Key, and Deer Island, which likely have robust Mole Skink populations. On some islands inhabited by Mole Skinks, only relatively short sections of their windward shorelines are suitable for searching. We failed to find Mole Skinks on Deadmans Key, Gomez Keys, Hog Island, Live Oak Island, Mclamory Key, Rattlesnake Island, Richards Island, and two unnamed islets, one of which no longer exists (Table 1). We could not confirm the occurrence of the species on Dog Island, which currently lacks suitable habitat. Most of these islands were surveyed only once and shoreline habitats are difficult to search. Live Oak and Richards Islands have potential habitat and suitable substrate for Mole Skinks.

Discussion

We suspect Cedar Keys Mole Skink populations are still extant on all nine islands where they have been reported. Of the 480 ha of available suitable habitat in the Cedar Keys, approximately 42% is found on Way Key and Airstrip Island, which are heavily developed (USFWS 2018b). A later analysis excluded urban landcover types, and Way Key and Airstrip Island consequently have only 1.9% of 77.5 ha of preferred habitat (i.e., beaches, dunes, and coastal hammocks) (USFWS 2023, 2024; Table 2). Although credible anecdotal reports of Mole Skinks exist from Way Key, Mount (1961, 1963) and we failed to find them there. We are unaware of any captures of Mole Skinks at the airport since runway modifications were completed; shoreline armoring disrupted the marine-terrestrial connection and altered the amount and composition of beach wrack and consequently potential invertebrate prey for Mole Skinks, particularly talitrid amphipods, flies, and beetles (Sobocinski et al. 2010; Heerhartz et al. 2014, 2016). However, apparently suitable shoreline habitat on private property on Airstrip Island probably still supports populations, as evidenced by an adult being found while cleaning up damage from Hurricane Idalia on 4 September 2023 just north of the airport under debris in a kitchen (UF-Herp 194121). According to Christman (1992), the once abundant population on Airstrip Island was drastically reduced in the past 15 years due to intense collecting by amateur reptile fanciers. We are unaware of any extensive collection of the taxon, except by scientists, and none were reported sold in 1990–1994 during a state program to collect information on the trade in native herpetofauna (Enge 2005).

Table 2. Maximum elevation, size, and potential (i.e., preferred nonurban) habitat of islands with records of the Cedar Keys Mole Skink (*Plestiodon egregius insularis*) (USFWS 2023).

Island	Maximum elevation (m)	Size (ha)	Potential habitat (ha)
Airstrip Island	4.9	12	0.4
Atsena Otie	6.4	74	10.7
Cedar Point	3.7	17	3.2
Deer Island	3.0	46	3.7
North Key	4.9	95	19.6
Scale Key	1.5	47	9.7
Seahorse Key	15.8	67	22.4
Snake Key	1.5	23	5.7
Way Key	11.3	28	1.1

We found all Cedar Keys Mole Skinks on or adjacent to higher energy beaches, usually at or above the high-tide line under dry or slightly moist wrack or other detritus, and sometimes along the ecotone between the beach and interior hammock. Loose sand and high prey availability, particularly amphipods (Mount 1963), likely account for the attractiveness of beaches. Christman (1992) claimed skinks could be found by raking loose sand at the base of trees in Seahorse Key's maritime hammock interior, but we could find no reports of them being found anywhere except along the beach. The University of Florida has a marine biology research station at the lighthouse on Seahorse Key, which has the highest elevation (15.8 m) along the Gulf Coast of Florida, and Wilder (1962) and other students found Mole Skinks along the beach that were not deposited in museum collections nor usually reported.

Populations likely occur in the forested interiors of most occupied islands, but we seldom searched these areas, likely biasing our assessment of the species' occurrence. Hammock populations probably serve as sources for recolonization of upper beaches after lizards are extirpated or displaced by storm surges. Some beach-dwelling skinks possibly could be washed into the higher hammocks during storm surges, but the steep scarps present between beaches and interior hammocks on high-elevation islands like Seahorse Key (Fig. 5) are likely to preclude skinks from climbing into hammocks

Figure 5. Beach on the windward side of Seahorse Key, Levy County, Florida, on 10 March 2015 (left), on 7 December 2016 ca. 3 months after Hurricane Hermine (center), and on 17 October 2023 after Hurricane Idalia showing additional erosion (right). Photographs by Kevin Enge.

to escape rising water levels. All known occupied islands that are undeveloped have interiors sufficiently elevated to support trees besides Black Mangroves (*Avicennia germinans*), usually Cabbage Palm (*Sabal palmetto*), Live Oak (*Quercus virginiana*), Laurel Oak (*Q. hemisphaerica*), Southern Redcedar (*Juniperus silicicola*), Redbay (*Persea borbonia*), and Yaupon (*Ilex vomitoria*). The understories often include Palmetto (*Serenoa repens*), Spanish Bayonet (*Yucca aloifolia*), Coontie (*Zamia integrifolia*), and Prickly Pear (*Opuntia* sp.). In the 1980s, freezes killed entire Black Mangrove forests in the Cedar Keys area, leading to revegetation of the intertidal zone by Smooth Cordgrass (*Spartina alterniflora*), but mangroves have since recolonized islands (Stevens et al. 2006). Only Scale and Snake Keys have maximum elevations < 3 m asl (Table 2), and Cedar Keys Mole Skinks have not been detected on either since 2004 (Table 1).

We usually only searched interiors of islands that lacked beach habitat suitable and convenient for searching, because detecting Mole Skinks is easier in the restricted, linear habitat of a shoreline than in the more extensive interior habitats with abundant litter and tree roots. Also, island interiors are usually shaded and have more shell than sand substrates, presumably rendering them less attractive to semifossorial Mole Skinks, and clearly more difficult for researchers to collect. These sand-swimming skinks were more likely to elude capture when raked out of shell-dominated substrate and the roots of vegetation, especially the heavy fibrous roots of palms. Richards Island has inconvenient shoreline habitat for searching, but its elevated interior hammock has openings in the canopy of predominantly Slash Pine (*Pinus elliottii*) and Live Oak (*Quercus virginiana*); much of the surface consists of open sand with leaf litter under or near shrub clumps and trees. This habitat is more typical of mainland than insular Mole Skink habitat, and we found five large Gopher Tortoise (*Gopherus polyphemus*) burrows.

We failed to observe suitable-sized invertebrate prey on some islands lacking Mole Skinks. Some unoccupied islands, such as Hog Island, are old shell middens and have predominantly oyster-shell substrates. Southern Redcedar is often the predominant tree species on shell substrates, and their fallen needles provide only a thin litter layer containing few arthropods. Essential oils of *Juniperus* that are laced with monoterpenes and higher terpenoid substances are highly noxious and even lethal to arthropods (Wedge et al. 2009), so hammocks dominated by Southern Redcedar are likely depauperate in invertebrate prey and seldom used by Mole Skinks. Redcedars were probably more prevalent in the past, but trees were heavily harvested in the late 1800s for the manufacture of pencils (McCarthy 2007; Oikel 2009).

We typically found skinks immediately under debris, including logs and washed-up Styrofoam, in tidal wrack or within the first 10 cm of loose, dry or slightly moist sand, but we found one inactive skink 20 cm deep in wet sand on North Key on 28 February 1993 (Table 1) after near-freezing temperatures the prior evening. On that same trip, we found six Green Anoles (*Anolis carolinensis*) on North Key (UF-Herp 87715–87718) and one on Scale Key (UF-Herp 87720) sheltering under tidal wrack. We also found Mole Skinks in dead or live grass or under dry wrack among the roots of Cabbage Palms, shrubs, and forbs. We found them under and within wet wrack along lower beaches only when the wrack had been heated by the sun and was warm to the touch, despite the presence at cooler temperatures of abundant potential prey, particularly amphipods, earwigs, spiders, and springtails. We occasionally found Mole Skinks in areas of sand and broken shells, and we saw one that was active on the surface in the afternoon among Glasswort (*Salicornia* sp.) in a tidal area on Airstrip Island. We occasionally observed hatchlings active on the surface, and an adult male was seen adjacent to tidal wrack on Atsena Otie in November 2023 (UF-Herp 194122). We found Cedar Keys Mole Skinks year-round, whereas Peninsula Mole Skinks on the mainland are difficult to find during hot summer months (Mount 1963; JMM, LAS, DCH, pers. obs.), although perhaps not at night (Neill 1974) or during drift-fence surveys (Dodd 2024). We suspect that periodic tidal inundation of beach microhabitats ameliorates temperatures, allowing Cedar Keys Mole Skinks to be diurnally active during the summer.

Rafting on floating debris and wrack is a passive dispersal mechanism for insular lizards (Williams 1969; Adler et al. 1995; Calsbeek and Smith 2003), and rafting has been identified as the most likely means by which Mole Skinks move between islands (Branch et al. 2003; USFWS 2018b). Rafting most likely occurs when skinks are displaced from beaches during strong storms. However, Mercier (2018) found no evidence of recent gene flow between islands for either insular subspecies of Mole Skink, and rafting between islands is probably highly unlikely (Adler et al. 1995; Censky et al. 1998; USFWS 2023, 2024). The maximum distance between occupied islands in the Cedar Keys is only 11 km, whereas gekkonids in the genus *Tarentola* apparently have rafted as far as 6,000 km on oceanic currents (Carranza et al. 2000). The Cedar Keys Mole Skink likely evolved on an isolated, larger upland area that was subsequently fragmented into small islands by sea-level rise and coastal erosion. The shoreline in the Big Bend region 10,000 years ago was at about the 40 m isobath in the Gulf of Mexico (Faught and Donoghue 1997), but rising sea levels from glacial melt resulted in the shoreline receding to the 3.65 m isobath 4,000 years later (Faught 2004). Seahorse Key, which is a 64-ha relict dune that was isolated from the mainland by rising sea levels, supports a population of Florida Wormlizards (*Rhineura floridana*), fossorial reptiles that are highly susceptible to drowning (Bogert and Cowles 1947). A Mole Skink found on Egmont Key, Hillsborough County (Smith et al. 1993; UF-Herp 84031), and photographs of specimens from coastal areas in nearby Pinellas (UF-Herp 202011–13) and Manatee (UF-Herp 202014) Counties resemble Cedar Keys Mole Skinks, suggesting that the range of this taxon might extend farther south than currently recognized. Because of the distinctiveness of the Mole Skink from Egmont Key, Koen et al. (2024) considered it when calculating impacts on insular Mole Skink habitat from sea-level rise.

Over one-half of adult Mole Skinks in museum collections and observed during our surveys had regenerated tails that probably reflected predation attempts. The most likely culprits are wading birds and Ghost Crabs (*Ocypode quadrata*), which we observed on many islands. Ghost Crabs are important mesopredators in littoral food webs, living in burrows and scavenging tidal wrack on beaches, especially at night (Hughes et al. 2014). They are known to feed on shorebird chicks and turtle eggs and hatchlings (Arndt 1991; Brown 2009; Peterson et al. 2013; Kwon et al. 2018). We observed flocks of White Ibis and Cattle Egrets foraging in the mowed grass along the airport runway. Islands closer to the mainland probably have more potential ophidian and mammalian predators, such as the Southern Black Racer (*Coluber constrictor priapus*), Eastern Kingsnake (*Lampropeltis* cf. *getula*), Raccoon (*Procyon lotor*), Nine-banded Armadillo (*Dasypus novemcinctus*), and feral Swine (*Sus scrofa*).

The range of the Cedar Keys Mole Skink is expected to decrease in the future as climate change causes sea levels to rise and the strengths of storms to increase. From 1850 to the early 1990s, the sea level at Cedar Key rose 20–25 cm (Raabe and Stumpf 2016). Insular Mole Skink populations are obviously adapted to storms, but rising sea levels will likely eliminate populations from the lower islands. Sea level at Cedar Key is predicted to rise 0.5–1.5 m by 2100, and a 0.9 m sea-level rise would mean that 77 ha (31%) of presently inhabited dry land in the Cedar Keys area would regularly flood (Frank et al. 2014). Cedar Keys Mole Skinks typically inhabit upland beach habitat 50–80 cm above sea level, which is susceptible to flooding, inundation, and saltwater intrusion (USFWS 2018b, 2023). Some low-lying islands have been washed away in the past decade, and other islands have experienced significant erosion likely exacerbated by climate change. Category-3 hurricanes impacted the Cedar Keys and destroyed most of the homes in 1842 and 1950 (McCarthy 2007; Oickle 2009).

On 2 September 2016, Hurricane Hermine (Category 1) caused 1.8–2.4 m above-average tides and a storm surge that washed across the City of Cedar Key. We visited Seahorse and North Keys three months later and found only a single Mole Skink on Seahorse Key. In contrast, we found three adults and nine hatchlings during a visit to North Key on 17 June 2015 prior to the hurricane. The entire beach area on Seahorse Key was scoured, exposing the roots of Cabbage Palms and eliminating the tidal wrack and other detritus under which Mole Skinks typically shelter. The cliff face separating the beach from the maritime hammock eroded further, causing trees to topple onto the upper beach (Fig. 5). Since Hurricane Hermine, the Cedar Keys area has been impacted less severely by Hurricane Michael in 2018, Tropical Storm Eta in 2020, and Tropical Storm Elsa in 2021.

On 30 August 2023, Hurricane Idalia (Category 3) caused a storm surge of 2.1 m in Cedar Key, and wave action on some offshore islands was more severe than during Hurricane Hermine. We visited North, Seahorse, and Snake Keys on 17 October 2023, about two months after Hurricane Idalia, and failed to find Mole Skinks. However, a Mole Skink was observed on Airstrip Island and Atsena Otie after the hurricane (Table 1). On 25 January 2024, we found one Mole Skink on North Key but none on Cedar Point, Scale, and Seahorse Keys. Seahorse Key apparently suffered the most damage from Hurricane Idalia, losing ~10 m of land on the windward side (Fig. 5). When we first visited Cedar Point in 2015, significant erosion was evidenced by dead tree stumps extending into the water more than 10 m from the shoreline. In 2022, many more dead trees were present on the beach on Cedar Point than seven years earlier when we found Mole Skinks (Fig. 6), and the coarse, woody detritus was no longer conducive to finding Mole Skinks. A steep scarp (ca.

Figure 6. Beach on Cedar Point, Levy County, Florida, on 17 July 2015 (left), 13 May 2022 (center), and 24 January 2024 after Hurricane Idalia (right), showing the dynamic nature of the shoreline. Photographs by Kevin Enge.

2 m high) prevented easy access to the island's interior, but Hurricane Idalia lowered the scarp and removed or buried most of the dead trees along the shoreline (Fig. 7). Islands with scarps separating their narrow, low beaches from their higher interiors typically have eroded sand deposited on their southern ends, which are stabilized by grasses and Glasswort. We have never found Mole Skinks in these areas of recently accreted sand, which lack suitable detritus and are frequently inundated during storms.

Since 1840, Mole Skink populations on Atsena Otie, Scale Key, Airstrip Island, and, presumptively, Way Key have had to survive human development and associated sources of mortality, including possibly house cats. Atsena Otie was the location of the town of Cedar Key until 1878, when most residents relocated to Way Key (Oickle 2009). In the 1880s, Cedar Key was the largest city in Florida and an important port (McCarthy 2007). Cedar Key had a population of 400 in 1870, 1,066 in 1930, and only 735 in 2020, but it is visited annually by thousands of tourists. In 1929, Cedar Keys National Wildlife Refuge was established to protect three islands with colonial breeding birds, and six islands occupied by Mole Skinks are now owned or managed as part of this refuge (USFWS 2024). Initially, the USFWS (2018b) determined that approximately 50% of the modeled potential habitat for the Cedar Keys Mole Skink is on islands in public ownership (USFWS 2018b). Of the 305 ha of available suitable habitat on islands where skinks have been detected, approximately 60% is found on developed Way Key and Airstrip Island and 36% on islands in public ownership (USFWS 2018b). Later, the USFWS (2023, 2024) excluded urban landcover layers, reducing the modeled potential habitat on Way Key and Airstrip Island by 98.8% from 127.4 ha to < 1.5 ha (Table 2). The fact that much of the habitat occupied by Cedar Keys Mole Skinks is protected on public land does not mean that populations are secure. Based on regional sea-level-rise projections, the USFWS (2018b) predicted that the nine skink-occupied islands are expected to lose 13–20% of their suitable habitat by 2040 and 16–62% by 2100. When urban areas were excluded as potential habitat, all populations except those on Cedar Point, Scale Key, and Seahorse Key were projected to be extirpated by high-tide flooding and sea-level rise by 2040 (USFWS 2023). Intermediate sea-level-rise models predict that > 65% of preferred habitat for the Cedar Keys Mole Skink will be inundated by 2100 (Koen et al. 2024). Based on the compiled data and survey detections that we provided, the USFWS (2024) decided that Dog Island and Snake Key had uncertain status because the last detection was before 2000 (the Dog Island detection was unconfirmed).

Despite its very small geographical range and its coastal habitat being susceptible to future sea-level rise and severe storms, the USFWS (2018a) determined that the Cedar Keys Mole Skink did not warrant listing because sufficient suitable habitat existed across its range to provide a level of resiliency, redundancy, and representation that would prevent extinction within the foreseeable future. However, the USFWS (2024) later proposed listing it as endangered because six of the currently occupied islands are projected to lose 75–90% of their preferred habitat because of sea-level rise, more frequent high-tide flooding, and increased intensity of tropical storms and hurricanes. In addition, the USFWS (2024) designated ca. 1,098 ha in 17 units as critical habitat. All units of critical habitat are within the historical range of the subspecies and contain the physical and biological features essential to its conservation (e.g., natural habitats, suitable soils, and sufficient and appropriate ground cover). Of the critical habitat, 34.7% is considered occupied and 52% is on government-owned conservation lands (USFWS 2024). Areas of critical habitat outside the currently known range of the subspecies are essential for its survival, and these include nine unoccupied islands (USFWS 2024), five of which we surveyed.

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Literature Cited

Adler, G.H., C.C. Austin, and R. Dudley. 1995. Dispersal and speciation of skinks among archipelagos in the tropical Pacific Ocean. *Evolutionary Ecology* 9: 529–541. https://doi.org/10.1007/BF01237834.

Arndt, R.G. 1991. Predation on hatchling Diamondback Terrapin, *Malaclemys terrapin* (Schoepff), by the Ghost Crab, *Ocypode quadrata* (Fabricius). *Florida Scientist* 54: 215–217.

Bogert, C.M. and R.B. Cowles. 1947. Results of the Archbold Expeditions. No. 58. Moisture loss in relation to habitat selection in some Florida reptiles. *American Museum Novitates* 1358: 1–34.

Branch, L.C., A.M. Clark, P.E. Moler, and B.W. Bowen. 2003. Fragmented landscapes, habitat specificity, and conservation genetics of three lizards in Florida scrub. *Conservation Genetics* 4: 199–212. https://doi.org/10.1023/A:1023398908793.

Brown, J.R. 2009. Factors affecting predation of marine turtle eggs by Raccoons and Ghost Crabs on Canaveral National Seashore, FL. Unpublished M.Sc. Thesis, University of Central Florida, Orlando, Florida, USA.

Calsbeek, R. and T.B. Smith. 2003. Ocean currents mediate evolution in island lizards. *Nature* 426: 552–555. https://doi.org/10.1038/nature02143.

Carranza, S., E.N. Arnold, J.A. Mateo, and L.F. López-Jurado. 2000. Long-distance colonization and radiation in gekkonid lizards, *Tarentola* (Reptilia: Gekkonidae), revealed by mitochondrial DNA sequences. *Proceedings of the Royal Society of London. Series B: Biological Sciences* 267: 637–649. https://doi.org/10.1098/rspb.2000.1050.

Censky, E., K. Hodge, and J. Dudley. 1998. Over-water dispersal of lizards due to hurricanes. *Nature* 395: 556. https://doi.org/10.1038/26886.

Christman, S.P. 1992. Cedar Key Mole Skink, *Eumeces egregius insularis* Mount, pp. 223–226. In: P.E. Moler (ed.), *Rare and Endangered Biota of Florida. Volume III. Amphibians and Reptiles*. University Press of Florida, Gainesville, Florida, USA.

Dodd, C.K. 2024. Activity, size, and tail damage of Peninsula Mole Skinks, *Plestiodon egregius onocrepis* Cope, 1871, around a Northeast Florida pond basin. *Herpetology Notes* 17: 259–263.

Enge, K.M. 2005. Commercial harvest of amphibians and reptiles in Florida for the pet trade, pp. 198–211. In: W.E. Meshaka, Jr. and K.J. Babbitt (eds.), *Amphibians and Reptiles: Status and Conservation in Florida*. Krieger Publishing Co., Malabar, Florida, USA.

Enge, K.M. 2019. *Plestiodon egregius* Baird 1859 "1859." Mole Skink, pp. 409–412. In: K.L. Krysko, K.M. Enge, and P. E. Moler (eds.), *Amphibians and Reptiles of Florida.* University of Florida Press, Gainesville, Florida, USA.

Enge, K.M., M.T. Fedler, P.E. Moler, T.M. Thomas, and B.W. Mansell. 2024. Correcting an *egregius* mistake: Redescription of the Cedar Keys Mole Skink. *Herpetological Review* 55: 325–330.

Faught, M.K. 2004. Submerged paleoindian and archaic sites of the Big Bend, Florida. *Journal of Field Archaeology* 29: 273–290. https://doi.org/10.2307/3250893.

Faught, M.K. and J.F. Donoghue. 1997. Marine inundated archaeological sites and paleofluvial systems: examples from a karst-controlled continental shelf setting in Apalachee Bay, northeastern Gulf of Mexico. *Geoarchaeology* 12: 417–458. https://doi.org/10.1002/(SICI)1520-6548(199708)12:53.0.CO;2-2.

Frank, K., D. Jourdan, and M. Volk. 2014. *Planning for Coastal Change in Levy County: Opportunities for Adaptation*. Florida Sea Grant, University of Florida, Gainesville, Florida, USA. <LC_Findings Report_10262014A.indd (wordpress.com)>.

Heerhartz, S.M., M.N. Dethier, J.D. Toft, J.R. Cordell, and A.S. Ogston. 2014. Effects of shoreline armoring on beach wrack subsidies to the nearshore ecotone in an estuarine fjord. *Estuaries and Coasts* 37: 1256–1268. https://doi.org/10.1007/s12237-013-9754-5.

Heerhartz, S.M., J.D. Toft, J.R. Cordell, M.N. Dethier, and A.S. Ogston. 2016. Shoreline armoring in an estuary constrains wrack-associated invertebrate communities. *Estuaries and Coasts* 39: 171–188. https://doi.org/10.1007/s12237-015-9983-x.

Hughes, R.N., D.J. Hughes, and L.P. Smith. 2014. The ecology of Ghost Crabs. *Oceanography and Marine Biology* 52: 201–256. https://doi.org/10.1201/b17143.

Koen, E.L., W.J. Barichivich, and S.C. Walls. 2024. Vulnerability of endemic insular mole skinks to sea-level rise. *Conservation Science and Practice* 6(9): e13208. https://doi.org/10.1111/csp2.13208.

Kwon, E., J.D. Fraser, D.H. Catlin, S.M., Karpanty, C.E. Weithman, and B. Muiznieks. 2018. Presence of Ghost Crabs and Piping Plover nesting success. *Journal of Wildlife Management* 82: 850–856. https://doi.org/10.1002/jwmg.21422.

McCarthy, K.M. 2007. *Cedar Key, Florida: A History*. History Press, Charleston, South Carolina, USA.

Mercier, K.P. 2018. Unearthing the past and present of a semi-fossorial lizard: conservation genetics, phylogeography, and taxonomy of *Plestiodon egregius*. Unpublished M.Sc. Thesis, University of Central Florida, Orlando, Florida, USA.

Mount, R.H. 1961. The natural history of the Red-tailed Skink, *Eumeces egregius* Baird. Unpublished Ph.D. Dissertation, University of Florida, Gainesville, Florida, USA.

Mount, R.H. 1963. The natural history of the Red-tailed Skink, *Eumeces egregius* Baird. *American Midland Naturalist* 70: 356–385. https://doi.org/10.2307/2423064.

Mount, R.H. 1965. Variation and systematics of the scincoid lizard, *Eumeces egregius* (Baird). *Bulletin of the Florida State Museum, Biological Sciences* 9: 183–213. https://doi.org/10.58782/flmnh.svzw4758.

Mount, R.H. 1968. *Eumeces egregius* (Baird). Mole Skink. *Catalogue of American Amphibians and Reptiles* 73: 1–2.

Neill, W.T. 1974. *Reptiles and Amphibians in the Service of Man*. Pegasus, Indianapolis, Indiana, and New York, New York, USA.

Oickle, A.F. 2009. *The Cedar Keys Hurricane of 1896: Disaster at Dawn*. History Press, Charleston, South Carolina, USA.

Peterson, C.H., S.R. Fegley, C.M. Voss, S.R Marschhauser, and B.M. VanDusen. 2013. Conservation implications of density-dependent predation by Ghost Crabs on hatchling sea turtles running the gauntlet to the sea. *Marine Biology* 160: 629-640. https://doi.org/10.1007/s00227-012-2118-z.

Powell, R., R. Conant, and J.T. Collins. 2016. *Peterson Field Guide to Reptiles and Amphibians of Eastern and Central North America*. Fourth Edition. Houghton Mifflin Harcourt Publishing Company, Boston, Massachusetts, USA.

Raabe, E.A. and R.P. Stumpf. 2016. Expansion of tidal marsh in response to sea-level rise: Gulf Coast of Florida, USA. *Estuaries and Coasts* 39: 145–157. https://doi.org/10.1007/s12237-015-9974-y.

Scott, J., K.M. Enge, L.A. Somma, and R.D. Bartlett. 2023. *Plestiodon egregius insularis* (Cedar Key Mole Skink). Reproduction. *Herpetological Review* 54: 299–300.

Sobocinski, K.L., J.R. Cordell, and C.A. Simenstad. 2010. Effects of shoreline modifications on supratidal macroinvertebrate fauna on Puget Sound, Washington beaches. *Estuaries and Coasts* 33: 699–711. https://doi.org/10.1007/s12237-009-9262-9.

Smith, L.L., R. Franz, and C.K. Dodd, Jr. 1993. Additions to the herpetofauna of Egmont Key, Hillsborough County, Florida. *Florida Scientist* 56: 231–234.

Stevens, P.W., S.L. Fox, and C.L. Montague. 2006. The interplay between mangroves and saltmarshes at the transition between temperate and subtropical climate in Florida. *Wetlands Ecology and Management* 14: 435–444. https://doi.org/10.1007/s11273-006-0006-3.

USFWS (U.S. Fish and Wildlife Service). 2018a. Endangered and threatened wildlife and plants; 12-month findings on petitions to list 13 species as endangered or threatened species. *Federal Register* 83: 65127–65134.

USFWS (U.S. Fish and Wildlife Service). 2018b. Species status assessment report for the Cedar Key Mole Skink (*Plestiodon egregius insularis*). Version 1.2. USFWS, Atlanta, Georgia, USA.

USFWS (U.S. Fish and Wildlife Service). 2023. Species status assessment report for the Cedar Key Mole Skink (*Plestiodon egregius insularis*). Version 2.0. USFWS, Atlanta, Georgia, USA.

USFWS (U.S. Fish and Wildlife Service). 2024. Endangered and threatened wildlife and plants; endangered species status for Cedar Key Mole Skink and designation of critical habitat. *Federal Register* 89: 65124–65159.

Wedge, D.E., N. Tabanca, B.J. Sampson, C. Werle, B. Demirci, K.H.C. Baser, P. Nan, J. Duan, and Z. Liu. 2009. Antifungal and insecticidal activity of two *Juniperus* essential oils. *Natural Product Communications* 4: 123–127. https://doi.org/10.1177/1934578X0900400127.

Wilder, C.D., Jr. 1962. Dominance-subordinance relationships in the Southeastern Five-lined Skink, *Eumeces inexpectatus* Taylor. Unpublished Ph.D. Dissertation, University of Florida, Gainesville, Florida, USA.

Williams, E.E. 1969. The ecology of colonization as seen in the zoogeography of anoline lizards on small islands. *Quarterly Review of Biology* 44: 345–389. https://doi.org/10.1086/406245.