SPECIES ASSESSMENT OF THE MIAMI TIGER BEETLE, CICINDELIDIA FLORIDANA

To: South Florida Ecological Services Office, 1339 20th St., Vero Beach, FL 32960

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Summary

The Miami Tiger Beetle, *Cicindelidia floridana* Cartwright is one of 109 described species in the Subfamily Cicindelinae of the Family Carabidae (ground beetles). The inclusion of tiger beetles as a subfamily and changes in generic designations for tiger beetles are based on recent studies which include genetic analysis. The Miami Tiger Beetle was described by Cartwright as a variety of *Cicindela abdominalis* from a series of 21 specimens collected in north Miami in 1934. It was considered extinct until rediscovered in 2007. A study in 2011 elevated it to a full species on the basis of several distinct morphological and biological characteristics. It was most similar to the Scabrous Tiger Beetle, *Cicindelidia scabrosa* but differed from that species by the green dorsal color, a more reduced maculation pattern, an extended adult activity period (May to October), the pine rockland habitat, and its restricted range in Miami-Dade County.

As typical of other tiger beetles, adults of the Miami Tiger Beetle are active diurnal predators which use their keen vision to detect movement of small arthropods and run quickly to capture these prey with their well-developed jaws (mandibles). The larvae are sedentary sit-and-wait predators that spend their life in permanent burrows flush with the ground surface, feeding on small arthropods which pass near the burrow mouth. The length of the development time of larvae through the three larval stages to the adult is one year or less. The five month long adult flight period is unusual in tiger beetles and much longer than for the other three species in the *Ci. abdominalis* group. This pattern may be a result of two cohorts of adults, one emerging in May and a second emerging in mid-summer from offspring that completed development from the early emerging adults.

The site of the original collection was apparently pine rockland but like most other pine rockland in Miami-Dade County has been lost to urbanization. Surveys of most of the remaining pine rockland sites found the Miami Tiger Beetle was restricted to a 1.2 sq km block of the Richmond Heights pine rockland area of south Miami: the Metrozoo pine rockland, University of Miami CSTARS campus, and the U. S. Coast Guard facility. These sites border each other on at least one side and because there are habitat connections, these represent a single population. Most of the surveyed sites without Miami tiger beetles were considered to be unsuitable because the vegetation was too dense, the substrate too high in rock cover, and/or a lack of sufficient open patches with sandy soil. Some of these sites may have supported populations in the past. Adults

of the Miami Tiger Beetles require open patches of sandy soil for thermoregulation, capturing prey and oviposition while the larvae need these patches to complete development without vegetation encroaching into their burrows.

Over 30 surveys from 2008 to 2014 to determine the distribution and abundance of adults at the Metrozoo found them at four separate patches, two of these with less than 10 individuals. One of the main zoo sites had peak counts of 17-22 in 2008 and 2009, but declined to 0-2 in six surveys from 2011 to 2014. The other main site had peak counts of 36 to 42 from 2011 to 2012 but 13 and 18 in 2014. One of two surveys of at CSTARS found a high count of 38 adults while only four were found in a more limited survey of some potential habitat at the Coast Guard site. The initial survey for larvae in January of 2010 found 63 larvae, most second and third instars, but January surveys of the same areas in 2011, 2012 and 2013 produced only 3-5 larvae. A January 2015 survey of the same area found 15 larvae. The cause of these lower numbers of adults and larvae in the recent surveys is uncertain but may be due to the observed increase in vegetation growth which resulted in a decrease in the size and number of suitable open patches of habitat. This increasing vegetation growth in the most important imminent threat to the Miami Tiger Beetle. Despite efforts to use prescribed fire as a management tool in pine rockland habitat, sites with the Miami tiger beetle are have not burned as frequently as needed to maintain suitable beetle habitat. Other probable threats to the Miami Tiger Beetle are impacts associated with the small size of this single population and stochastic factors that increase the chances of extinction. The effects of climate change and sea level rise are uncertain, but predictions of a greater frequency of storm events, reduced or more erratic rainfall and especially changes in water level or hydrology could impact the species. The existence of larvae in shallow permanent burrows throughout their development makes them susceptible to changes in ground water level and moisture. Although tiger beetles are a heavily collected group of insects by amateurs, the existing gating and monitoring of the current sites are likely to reduce this impact to the Miami Tiger Beetle. Another more serious threat to the Miami Tiger Beetle is a proposed theme park that could eliminate existing or potential habitat or disrupt management options important for the survival and conservation of this extremely rare species.

There are management strategies that if implemented soon could significantly improve the status of the Miami Tiger Beetle. Burning or other methods for reducing vegetation density and encroachment could probably increase population size by increasing amount and quality of habitat at all sites, especially at the Metrozoo. Another approach that has worked for other tiger beetles is the establishment of new populations by translocation at existing pine rockland sites which may have suitable habitat or be restored to quality habitat. Experience with tiger beetles indicate this is possible.

Species Description

The Miami Tiger Beetle, *Cicindelidia floridana* Cartwright is one of 109 described species in the Subfamily Cicindelinae of the Family Carabidae (ground beetles). Previously, tiger beetles were considered a separate family by many workers but are now classified as a subfamily of the family Carabidae on the basis of recent genetic studies and other characters (Erwin and Pearson

2008) New treatments of tiger beetles (Bousquet 2012, p.30; Pearson et al. 2015, p. 138) have also elevated most of the previous subgenera of tiger beetles to genera, resulting in a change of the genus of the tiger beetles in the *C. abdominalis* group which includes the Miami Tiger Beetle from *Cicindela* to *Cicindelidia.* This new generic designation was used in the recent description for the recently described Miami Tiger Beetle, *Cicindelidia floridana* (Brzoska et al. 2011). These genera were originally proposed by Rivalier (1954, entire) and widely used by European workers (Wiesner 1992) but considered subgenera by many American workers. The return to Rivalier's system has also been supported by a new study using genetic evidence (Duran and Gwiazdowski, in preparation).

The Miami Tiger Beetle has the elongate oval shape with bulging eyes characteristic of other tiger beetles, but is one of the smallest (6.5-9 mm) of the U. S. tiger beetles (Fig. 1). It has a shiny dark green dorsal surface, sometimes with a bronze cast and without close examination in the field may appear black. The underside of the abdomen is orange to orange-brown in color like many other *Cicindelidia*. The pair of green hardened forewings covering the abdomen (elytra) have reduced white markings (maculations) consisting only of a small patch at the posterior tip of each elytron.

As is typical of other tiger beetles, adults of the Miami Tiger Beetle are active diurnal predators which use their keen vision to detect movement of small arthropods and run quickly to capture prey with their well-developed jaws (mandibles). Observations by various workers indicate small arthropods, especially ants are the most common prey for tiger beetles. This may also be true for the Miami Tiger Beetle because ants are very common where the beetles occur. Willis (1967, p. 196-197) lists over 30 kinds of insects from many families as prey for tiger beetles and scavenging is also common in some species (Knisley and Schultz 1996, p.39, 103). Choate (1996, p. 2) indicated ants were their most common prey of tiger beetles in Florida. Tiger beetle larvae have an elongate white grub-like body and dark or metallic head with large mandibles. Larvae are sedentary sit-and-wait predators occurring in permanent burrows flush with the ground surface. When feeding, larvae position themselves at the burrow mouth and quickly strike at and seize small arthropods which pass within a few cms of the burrow mouth. An enlarged dorsal portion of the fifth abdominal segment with two pairs of hooks anchor the larvae into its burrow while the upper portion of the body extends to capture prey. Their arthropod prey is similar to that of adults.

Taxonomy (including genetic work)

Cicindelidia floridana is one of four tiger beetle species in the *Ci. abdominalis* group that also includes *Ci. abdominalis, Ci. highlandensis* and *Ci. scabrosa*. These species share a small body size (7-11 mm long), orange underside and occur in inland sandy habitats away from water and with separate ranges along the Atlantic Coastal Plain. These four species exhibit a significant gradient in decreasing range size from *Cicindela abdominalis* which occurs from New York south along the coastal plain to north Florida, to *C. scabrosa* present throughout much of peninsular Florida south to Ft. Lauderdale, to *C. highlandensis* that is restricted to the Lake Wales Ridge of Highlands and Polk Counties and to *Ci. floridana* which is found only in Miami-Dade County. Cartwright (1939) described *Ci. floridana* as a variety (subspecies?) of *C.*

abdominalis, *C. abdominalis* var. *floridana* from a series of 21 specimens collected by Frank N. Young in Miami in August of 1934 (Fig. 1). The short four-line description distinguished this form by the "shining green color of the head, thorax and abdomen, the latter with purplish reflections posteriorly at the sides" and "strong deep punctures and fovea of the elytra" (Cartwright 1939). The other three related species are all shiny black dorsally.

In a review of the species in the *abdominalis* group, Choate (1984, pp. 73-82) described a new species, *Cicindela highlandensis* Choate, and elevated *Cicindela scabrosa* Schaupp to species level. In that paper he created "*C. scabrosa floridana*" with no mention of types or other details except for a comment on variation in *C. scabrosa* that "some specimens are quite greenish (i.e. *floridana*)" which he considered to be an indication of recent adult emergence. Apparently Choate considered var. *floridana* as a subspecies of *C. scabrosa* because both had similar sculpturing on the elytra and dense flattened setae on the pronotum. In his more recent book on Florida and Eastern U.S. tiger beetles Choate (2003) does not mention *C. s. floridana*, possibly because of the paucity of specimens and the assumption of most researchers that it was extinct. Pearson et al. (2006) referred to *C. s. floridana* in their treatment of *C. scabrosa* as "an isolated population in the Miami area that has been considered a subspecies, *C. scabrosa floridana* (Cartwright), which is smaller than the nominate form and distinctly green above." They indicated this population had not been observed for more than 50 years and was probably extinct because of habitat destruction and urbanization.

The rediscovery of a population of this tiger beetle at the Miami Metro Zoo pine rockland preserve in 2007 provided additional specimens and prompted a full study of its taxonomic status (Brzoska et al. 2011). The results of that study elevated it to a full species, *Cicindelidia floridana* on the basis of several characteristics that distinguish it from the three other species of the *abdominalis* group. It was most similar to *C. scabrosa* but differed from that species by the green dorsal color, a more reduced maculation pattern, an extended adult activity period (May to October), the pine rockland habitat, and its restricted range in Miami-Dade County. This array of distinctive characters is comparable to the characters used to separate the other three species of the *C. abdominalis* group. These other three species have an adult activity period limited to May through August.

Another study of the *abdominalis* group used mtDNA analysis to evaluate genetic relationships of the four species (Knisley 2011). This study included two genes, cob with 385 bp and cox1with 772 bp, analyzed separately and together. The results found that all *Cicindelidia floridana*, *Ci. highlandensis* and *Ci. scabrosa* haplotypes coalesced under nested clade analysis into a single network with no discrete separations between nominal species. The monophyly of *Ci. floridana*, *Ci. scabrosa*, and *Ci. highlandensis* was well supported in all reconstructions. However, *Ci. floridana and highlandensis* were found to be paraphyletic with respect to *Ci. scabrosa*. In the case of these tiger beetle species, the lack of a distinct separation matching the above standard taxonomic results is not unusual and could be a result of the shortness of internodes. Indeed it should be emphasized that the power of DNA sequencing for species resolution is limited when species pairs have very recent origins, because in such cases new sister species will share alleles for some time after the initial split due to persistence of ancestral polymorphisms, incomplete lineage sorting, or ongoing gene flow (Sites and Marshall, 2004). An extensive review of mtDNA studies retrieved species-level paraphyly or polyphyly in 23% of 2319 recognized species surveyed; this phenomenon was taxonomically widespread, statistically supported, had a variety of sources, and was far more common than generally expected (Funk and Omland, 2003). It is likely that the changing sea levels and coincidental changes in the size of the land mass of peninsular Florida during the Pleistocene Era (2.6 mya to 10,000 years ago) was the key factor in the very recent divergence and speciation of the three Florida species from *Ci. abdominalis.*

A formal description of the third instar larva of the Miami Tiger Beetle has also be completed using larvae that were reared in the laboratory from field collected adults (Knisley and Wirth 2013). This description and that of the three other species of the *abdominalis* group is being completed and will be submitted for publication (Wirth, personal communication).

Life History (instar development, adult flight season, and mating)

Development and Activity. With tiger beetles, the adult female determines the habitat and microhabitat of the larva by the selection of an oviposition site (Knisley and Schultz 1997, p. 28). Usually but not always it is the same microhabitat occupied by adults. Females will often touch the soil with the antennae, bite it, and even dig trial holes, possibly to determine suitable soil characteristics (Willis 1967, p. 194) before placing a single egg into a shallow ovipositon burrow (1-2 cms) dug into the soil with the ovipositor. The egg hatches, apparently after sufficient soil wetting and the first instar larvae digs a burrow at the site of oviposition. Development in tiger beetles includes three larval instars followed by a pupa and adult which in most species requires two years but ranges from one to four or more years depending on climate and food availability.

The life cycle of most U. S. tiger beetles follows either a summer or spring-fall adult activity pattern (Knisley and Schultz, 1997, p. 19-21). In the summer pattern a new cohort of adults emerges in mid-May to early June, almost immediately mate and oviposit. They remain active until about mid- August when numbers decline drastically as individuals die off. Larvae from these adults develop to the second or third instar by winter and continue development in the spring to the third instar followed by pupation; in some cases if eggs were laid late or food is limited, emergence would not occur until the second year. Adults exhibiting the spring fall pattern emerge as new adults in March or April, soon mate and oviposit before dying off in early summer. Their larvae develop and overwinter usually as second instars and continue developing before emerging the following year or two years later in spring. A second cohort of new adults emerges in late August to early September and remains active and sexually immature before digging overwintering burrows in early October before re-emerging the following spring. Variations in the spring-fall pattern include a winter activity pattern (January to April) for the Ohlone Tiger Beetle and as indicated below a four month development period for some populations of the Hairy-necked Tiger Beetle (*C. hirticollis*) with offspring of the spring adults emerging as sexually immature new adults in the fall of the same year. With these life cycles patterns the length of the adult flight season is typically 2-3 months, but the life span of individual adults is likely to be less.

Results of monthly surveys at the Metro zoo site in 2009 and additional late summer and fall surveys through 2014 indicated the adult flight period for *C. floridana* ranges from May 15 through October 17 (Fig. 2). No adults were found during an April 18 survey meaning emergence had not yet occurred. In 2009, only two adults were found on September 2 either because conditions were not ideal (although they seemed to be suitable) or activity may have ended earlier than in 2009. In 2014 some adults were active on September 10 and 30 but not on October 14. This five month long adult flight period is unusual in tiger beetles and much longer than the seasonality of the other three species in the *Ci. abdominalis* group. These other three species have the typical summer active seasonality, emerging in mid-May (like *Ci. floridana*), and remaining active until late July to early August; a small percentage of *Ci. abdominalis* in the northern part of its range may remain active into late August or early September. In central and south Florida, records indicate *Ci. scabrosa* and *Ci. highlandenis* are active from mid-May to late July or early August. This difference in seasonality is considered a valid character for distinguishing the Miami Tiger Beetle from these sister species.

There is no clear explanation for the long adult flight period of the Miami Tiger Beetle, but since the life span of adult tiger beetles in the field is typically no more than 2-3 months and apparently less for individuals, it is possible that there are two cohorts of adults emerging during this period. Adults emerging in May and June would mate, oviposit and produce larvae that could develop and emerge as a second cohort of adults in late July and August as the earlier cohort of adults were dying off. Larvae from these later active adults would develop through fall and winter, emerging as adults the following May. The rapid completion of development within two months would not be unusual given the small size of this species and the continually warm temperatures in south Florida. Rate of development is also likely to be increased during the summer rainy season when more prey would be present. By comparison, a study of *Cicindela hirticollis*, a much larger species in Maryland where lower spring and early summer temperatures would reduce activity, completed development in less than four months (Knisley and Schultz 1997, p. 110). An alternative to the two cohort hypothesis is that there is prolonged continual asynchronous emergence of new adults for most of the period from May into late summer. This seems less likely because what is known about tiger beetle life cycles indicates development with a synchronous emergence of adults (Knisley and Schultz 1997, p. 21-22). The only other tiger beetles with a similar prolonged adult activity period are several species in south Texas. *Cicindela nevadica, C. pamphila,* and *C. circumpicta* emerge in May and can be found into November and even December (Knisley, unpublished studies). It is believed that these early emerging adults produced offspring in May and June and these develop and emerge as a new cohort of adults in late summer to early fall and remain active into November and December.

Historic Range, Current Range, Habitat, Microhabitat

The historic and current range of the Miami Tiger Beetle includes only two locations, the type locality in north Miami and the only known extant sites in the Richmond Heights of south

Miami. The exact location of the type locality was determined by Rob Huber, a tiger beetle researcher who contacted Frank Young in 1972. Young related collecting the type series while searching for land snails at the northeast corner of Miami Avenue and Gratigny Rd. (119th St.). Huber checked that location the same year and found a girls school had been build there. A more thorough search for sandy soil habitats in 1991 by Knisley and Hill (1991) found no potential habitat throughout that area. Although contact with Young did not indicate the habitat type, it was likely to be pine rockland with some sandy soils since this is the habitat of the current Miami Tiger Beetle sites and a 1943 map of habitats in the Miami area showed pine rockland with sandy soils reaching their northern limit in the area of the type locality (Fig. 3). Additional confirmation was a reference to pine rockland habitat in Young's paper on land snails (Young 1951, p 6). An examination of recent aerials show that pine rockland is now gone from this area and is restricted to preserved sites in south Miami.

The only sites where the Miami Tiger Beetle now occurs are three contiguous patches of pine rockland habitat in the Richmond Heights area of south Miami. These three sites, ownership and peak numbers counted are, as follows:

		Peak Number Counted		
Site Name	Parcel Owner	2008-2011	2012	2013-2014
Zoo Miami	Miami-Dade County	42	36	18*
CSTARS	University of Miami	38	no survey	0**
U.S. Coast Guard	U. S. Coast Guard	4^	no survey	3^^

* Survey by D. Brzoska and J. Stamatov
** Survey inconclusive, end of flight season
^ Some potential habitat not surveyed
^ ^ Fairchild Garden/ Institute for Regional Conservation plant survey

Characteristics of Pine Rockland. (from www.fws.gov/vbpdfs/commun/pr.pdf). Pine rockland occurs on relatively flat, moderate to well-drained terrain. Drainage varies according to the porosity of the limestone substrate, but it is generally rapid. The three regions where pine rocklands occur in Florida have unique geological attributes. In Miami-Dade County the community is associated with the Miami Rock Ridge, a formation of Miami oolitic limestone which extends for 70 miles from northeastern Miami-Dade County to the Mahogany Hammock region of Everglades NP (DERM 1993, 1994). The surface is often irregular with solution holes up to several meters in width and depth. The elevation varies from greater than 7 m above sea level in the Miami area to less than 2 m above sea level in the Long Pine Key. The pine rocklands of the Miami Rock Ridge have been divided into three separate regions by Robertson (1955) based on soil patterns. The known range of the Miami Tiger Beetle is restricted to the northern end of the ridge, the Northern Biscayne Pinelands, which extends south to approximately SW 216th St. This part of the pine rockland is characterized by extensive sandy pockets of quartz sand classified as Opalocka sand-rock outcrop complex, the sand component a feature that is necessary for the Miami Tiger Beetle and would explain the beetles presence in this area.

Habitat and Microhabitat. Common tiger beetle habitats include water edges, sand dunes, sparse grasslands, open areas in woodlands, and other habitats with open patches of bare ground. Adult tiger beetles need these open areas for behavioral thermoregulation to attain the high body temperatures so they can successfully capture small arthropod prey. They are visual hunters that use keen eyesight to locate and rapid movement to capture small arthropods. Females oviposit in these same bare patches so their larvae which are sit and wait predators can capture prey and complete development without interference from encroaching vegetation. These critical microhabitat parameters of bare patches of sandy soil are absent or of limited occurrence in many of the pine rockland sites, but present in the Richmond sites where the Miami Tiger Beetle is found. Dominant vegetation around the open patches at these sites is palmetto, grasses, *Opuntia*, cabbage palms and oaks under a mostly open canopy of scattered slash pines (Fig. 4). In the areas of open canopy the ground surface is exposed to sunlight most of the day, but where pines are dense there is too much shade for adults to engage in their normal activities (foraging, mating, oviposition). The ground surface in these dense pine areas were also unsuitable because they were heavily covered with pine litter.

The above information on the pine rockland community suggests certain features that are likely to provide suitable habitat for the Miami Tiger Beetle and offers insight to its current distribution. The higher elevation, rapid drainage, and accumulated patches of sandy soil in the Northern Biscayne Pinelands section are more likely to be favorable for tiger beetles and may explain why we found the Miami Tiger Beetles only in this section of pine rockland habitat. It may also be the case that the past history of other pine rockland sites may explain their absence. Even though some of these sites now seem suitable, the lack of fires or management to reduce vegetation density in the past could have resulted in the loss of open patches that beetles need and consequently the extirpation of populations that occurred there.

Although the MTB is now and has apparently in the past been restricted to pine rockland habitat, it is likely that the physical features, particularly the vegetation structure and especially soil characteristics are more important in defining habitat and microhabitat rather than plant species. However, plant species like the Deltoid Spurge and Tiny polygala that have the same or similar microhabitat preference and co-occur with the MTB could be important indicators of beetle habitat.

Microhabitat. At the Metrozoo Pine Rockland which was most thoroughly surveyed, adults and larvae were restricted to a small number of scattered patches of bare ground. The patches were small, typically 2-6 sq m in size and ovoid to linear in shape (Figs. 5) with encroaching and overhanging vegetation around the edges and with 15-30% ground cover of leaf, grass and plant litter. Smaller patches typically had no adults. Some of the more linear patches were apparent current or past trails or paths, probably maintained by animal activity (Fig. 5). Soil in these open patches where adults and larvae were found was classified as sandy to loamy sand with primarily very fine (.125 mm) to medium grain (0.50m) white to gray colored sand with $<5\%$ organic matter (Knisley 2011, p. 32). Soil depth was six or more inches deep and moist below the surface. This microhabitat is different from that of the sister species *Ci highlandensis* and *Ci. scabrosa* which in Florida are typically found in much larger naturally open patches among the vegetation (usually over 25 sq. m) or along open paths, roads, and scrub edges. The sand for these other species is also yellow or white "sugar" sand and very deep, drier and with little organic matter mixed in.

Sites without the Miami Tiger Beetle

The Miami Tiger Beetle is similar to its three sister species in being restricted to sandy soils in sparsely vegetated woodlands, but is much more restricted in range and apparently habitat type. The results of surveys of over 40 sites with pine rockland or scrub habitats from 2008-2010 found the Miami Tiger Beetle was absent from 17 pine rockland sites (16 in Miami Dade, 1 in Monroe) and from 25 scrub sites in Miami-Dade, Broward, Palm Beach and Martin Counties (see Appendix). The sister species, *C. scabrosa* occurs at various sites in the counties north of Miami-Dade; the closest to the range of *C. floridana* is a record for Ft. Lauderdale Executive Airport, about 20 miles north of the type locality of *Ci. floridana*.

The absence of the Miami Tiger Beetle from the sites north of Miami-Dade was probably because it never ranged beyond pine rockland habitat of Miami-Dade County and into scrub habitats to the north. Why it was absent from most Miami-Dade sites is uncertain, but several factors may be involved. From our site surveys it was apparent that most of the negative sites had vegetation that was too dense and/or was lacking the suitable of open patches of sandy soil. Some sites had most or all of the bare areas with a rocky substrate and without any of the sandy patches needed by adults for oviposition and larval habitat. A few sites had evidence of disturbance from human activity that could have a negative impact on beetles. It was interesting that beetles were also absent from some sites that seemed to have the necessary habitat and microhabitat characteristics, even some with more open areas and suitable patches of sand. Among the most promising of these sandy pine rockland sites in south Miami which seemed to have potential habitat were Nixon Smiley, Pineshore, Ludlam, and Deering Estate. Sites bordering the zoo site, Larry and Penny Thompson Park and Martinez Pineland, also had very similar habitat to the sites with beetles, but no beetles were found at any of these. Nixon Smiley (Fig. 6) seemed to be ideal with even more open areas and sandy patches than the extant sites, but beetles were not found for unknown reasons. Martinez (Fig. 7) was in close proximity to the three occupied sites and seemed to have some potential habitat although the substrate was very rocky in most areas. As indicated above, the absence of the Miami Tiger Beetle from these sites may have been due to their being extirpated by the development of dense vegetation in the past prior to management. Some of these sites may be suitable for the establishment of new populations by translocation.

Population estimates and status

The Miami Tiger Beetle is currently listed as S1 and G1 by the Florida Natural Areas Inventory. It was recently listed by NatureServe as G1.

The three sites with extant populations of the Miami Tiger Beetle are within an approximate 2.0 sq. km block of the Richmond Heights pine rockland area of south Miami (Fig. 8). The size of this block was determined by using the Google Earth measuring tool to measure the perimeter of the three contiguous occupied sites (Metrozoo pineland, University of Miami CSTARS campus and the U. S. Coast Guard facility). However, it is estimated that less than 10% of the mostly pine rockland within this area supports the species. Because of the close proximity of these three sites and apparent connecting patches of habitat with few or no barriers, there is likely to be frequent movement by adults among sites. Consequently, this occurrence probably represents a single population rather than a metapopulation.

Surveys were much more frequent and thorough at the Metrozoo site than the other two sites. On over 30 survey dates from 2008 to 2014 adults were found in four separate patches of habitat (Figure 8). Two of these patches had less than ten adults during several surveys at each. The more northern site (A) where adults were first discovered had peak counts of 17-22 in 2008 and 2009, but declined to 0-2 in six surveys from 2011 to 2014 despite thorough searches on several dates (Table 1). On 22 August 2008, the 17 adults were found in 7 of 23 patches. Site B, south of A had peak counts of 42 in 2011 and 36 in 2012 but lower peak counts of 20 in 2008, 17 in 2009, and 13 and 18 in 2014 (Fig. 2). On 11 August 2011, the 42 adults were found in 19 separate patches with 1 to 7 adults per patch; 7 patches had no adults. On 16 July 2014, the 13 adults in site B were found in 7 patches while 6 other patches had no adults. These surveys at both A and B documented a decline in both occupied and unoccupied patches between 2008-2009 and 2014. At site A the decrease was from 7 occupied of 23 patches in 2008 to 1 occupied of 13 patches in 2014. At site B, the decrease was from 19 occupied of 26 patches in 2008 to 7 occupied of 13 patches in 2014.

At the CSTARS site the only survey during peak season was on 20 August 2010 when much of the apparent habitat was checked. This survey produced a count of 38 adults in 11 scattered habitat patches, 1 to 9 individuals per patch, mostly in the western portion of the site (Fig. 7). Two additional visits were only spot checks for photography or collection of representative voucher specimens. Three surveys at the U. S. Coast Guard included only a portion of the potential habitat and produced adult counts of 2, 4, and 2 adults in three separate patches. Additional surveys of the CSTARS and the Coast Guard sites on 14-15 October 2014 included areas where adults were previously found and some new areas, but no adults were found apparently because the flight season had ended. It was notable that the patches that previously supported adults seems smaller due to increased vegetation growth, and consequently less suitable than in the earlier surveys.

Surveys of adult numbers over the years especially the frequent surveys in 2009 did not indicate a bimodal activity pattern although more study is needed to confirm the cause of the prolonged period of adult activity . It should be emphasized that the actual number of adults is likely to be 2-3 times higher than indicated by the index counts. Several studies comparing methods for estimating population size of several tiger beetle species, including the Highlands Tiger Beetle found total numbers present were usually more than two times that indicated by the index counts (Knisley 2007, Knisley and Hill 2013). The underestimates are likely to be comparable or greater for the Miami Tiger Beetle because its small size and occurrence in small open patches where individuals can be obscured by vegetation around the edges make detection especially difficult.

Surveys for larvae at the Metrozoo site (patches A and B) were conducted in several years during January when lower temperatures would result in a higher level of larval activity and open burrows (Knisley and Hill 2013, p. 38). The first survey in January, 2010 produced a count of 63 larval burrows, including 5 first instars, 36 second instars and 22 third instars (Table 1). These burrows were marked with numbered metal tags attached to the ground with nails. All burrows were in the same bare sandy patches where adults were found. Of the total, 35 were in the northern section (A) in 12 of 20 patches surveyed. One patch had 7 burrows, two had three burrows and the remainder had 1-2 larvae. The 28 burrows in the more southern section (B) were in 8 of 16 patches surveyed. One patch had 4 burrows, three had three burrows and four had 1-2 burrows. A follow up survey in March 2010 indicated most second instar larvae had progressed to the third instar. Additional surveys to determine larval distribution and relative abundance during January or February in subsequent years produced fewer larvae, all in the southern section: 5 in 2011, 3 in 2012, 3 and 5 in 2013, and 15 in 2015. The reason for this significant decline in larval numbers is unknown. Possible explanations are that fewer larvae were present because of reduced recruitment by adults in 2010-2013, increased difficulty in detecting larval burrows that were present or a combination of these two factors. As noted the increasing encroachment of vegetation into the open patches during this period could have resulted in more burrows being obscured and thus not detectable during the survey. Surveys for larvae and adults in 2015 and 2016 will be important in determining if the population is actually declining.

Past and current threats to the species

Habitat loss and modification.

<u>Development, land conversion and habitat loss </u>(This section taken from FWS draft assessment with slight modification). The Miami tiger beetle has experienced substantial destruction, modification, and curtailment of its habitat and range (Brzoska *et al*. 2011, pp. 5-6; Knisley 2013, pp. 7-8, Knisley 2014, p.2). The pine rockland community of south Florida, on which the beetle depends, is critically imperiled globally (FNAI 2013, p. 3). Destruction of the pinelands for economic development has reduced this habitat by 90 percent on mainland south Florida (O'Brien 1998, p. 208). The only known population of the Miami tiger beetle occurs within the 3 patches of Richmond Pine Rocklands on publicly or privately owned lands that are partially developed, yet retain some area of undeveloped pine rockland habitat Any unknown extant Miami tiger beetle populations or suitable habitat that may occur on private lands or non-conservation public lands, such as elsewhere within the Richmond Pine Rocklands or adjacent areas, are vulnerable to habitat loss. In 2013, plans for the potential addition of a theme park to Zoo Miami were announced in local newspapers (Munzenrieder 2013, entire) after the County solicited an "invitation to negotiate" for development of the Zoo Miami Entertainment Area (ZMEA). The "invitation to negotiate" solicited proposals from "one or more experienced and capable parties to finance, develop, construct and operate under various lease, license and concession agreements multiple attractions, amusements, lodging, food service and retail establishments within Zoo Miami, Gold Coast Railroad Museum Park and Coast Guard properties collectively known as the Zoo Miami Entertainment Area..."
https://www.miamidade.gov/dpmww/SolicitationDetails.aspx?Id=Invitation%20To%20Negotiat

e%20(ITN) [Accessed April 24, 2014]. It appears that current plans are for Miami-Dade County to negotiate with two companies for the ZMEA (Miami Today 2014, entire), although no details are available on the exact footprint for the proposed entertainment complex or its potential impact on the Miami tiger beetle and other imperiled species.

Fire suppression and succession. The threat of habitat destruction or modification is further exacerbated by a lack of adequate fire management (Brzoska *et al*. 2011, pp. 5-6; Knisley 2013, pp. 7-8, Knisley 2014, p.2). Historically, lightning-induced fires were a vital component in maintaining native vegetation within the pine rockland ecosystem, as well for opening patches in the vegetation required by the beetles (Loope and Dunevitz 1981, p. 5; Slocum *et al*. 2003, p. 93; Snyder *et al.* 2005, Knisley 2011, pp. 31-32). Open patches in the landscape, which allow for ample sunlight for thermoregulation, are necessary for Miami tiger beetles to perform their normal activities, such as foraging, mating, and oviposition (Knisley 2011, p. 32). Larvae also require these open patches to complete their development free from vegetation encroachment. Without fire, successional climax from tropical pineland to hardwood hammock is rapid, and displacement of native plants by invasive nonnative plants often occurs, resulting in vegetation overgrowth and litter accumulation in the open bare sandy patches that are necessary for the Miami tiger beetle. It has been reported that in the absence of fire, pine rockland will succeed to tropical hardwood hammock in 20 to 30 years (Alexander 1967, Wade et al. 1980, Loope and Dunevitz 1981, Snyder et al. 1990. A thick duff layer accumulates and eventually results in the appearance of humic soils rather than mineral soils.

Miami-Dade County has implemented various conservation measures, such as burning in a mosaic pattern and on a small scale, during prescribed burns in order to help conserve the Miami tiger beetles and other imperiled species and their habitats (J. Maguire, pers. comm. 2010). Miami-Dade County Parks and Recreation staff has burned several of their conservation lands on fire return intervals of approximately 3 to 7 years. In addition, prescribed burns on large conservation areas, such as parcels within the Richmond Pine Rocklands, have been conducted in a cyclic and systematic pattern, which has provided refugia within or adjacent to treatment areas. This management appears to have benefited the beetle since it has continued to survive at these three sites over the years and to the present time.

Despite efforts to use prescribed fire as a management tool in pine rockland habitat, sites with the Miami tiger beetle are often not burned as frequently as needed to maintain suitable beetle habitat. Area A of the Metrozoo pineland was burned in November 2014 resulting significant removal of ground and understory plants and hopefully creating new habitat areas for the Miami Tiger Beetle (Fig. 10). Other pineland at this site was last burned in January and October of 2007. By 2010, there was noticeable vegetation encroachment into suitable habitat patches (Knisley 2011, p. 36) (Fig. 8). Several occupied locations at the University of Miami CSTARS site were burned in 2010, but four other locations at CSTARS were last burned in 2004 and 2006 (Knisley 2011, p. 36). No recent burns are believed to have occurred at the USCG site (Knisley 2011, p. 36). The decline in adult numbers at the two primary patches Metrozoo patches in 2014 surveys and the failure to find larvae there in recent years may be a result of the continued loss of bare open patches which observations suggest have occurred (Fig. 8A)(Knisley 2014). Benefits from the 2014 burn could be indicated by increased numbers of adults and larvae in 2015-2016 surveys. Surveys of the CSTARS and Coast Guard site in 2014 were too late to determine adult activity, but there was apparent declining habitat quality from encroaching vegetation (Knisley 2014, p.)(Fig. 8B. Survey in 2015 are needed to determine if numbers of beetles at these sites have also declined.

Impacts of nonnative species. Nonnative plants have significantly affected pine rocklands (Bradley and Gann 1999, pp. 15, 72; Bradley and Gann 2005, page numbers not applicable; Bradley and van der Heiden 2013, pp. 12–16). As a result of human activities, at least 277 taxa of nonnative plants have invaded pine rocklands throughout south Florida (Service 1999, pp. 3-175). *Schinus terebinthifolius* (Brazilian pepper) , a nonnative tree, is the most widespread and one of the most invasive species. It forms dense thickets of tangled, woody stems that completely shade out and displace native vegetation (Loflin 1991, p. 19; Langeland and Craddock Burks 1998, p. 54). *Neyraudia neyraudiana* (Burma Reed), *Acacia auriculiformis* (earleaf acacia), *Rhynchelytrum repens* (natal grass), *Lantana camara* (shrub verbena), and *Albizia lebbeck* (tongue tree) are some of the other nonnative species in pine rocklands. More species of nonnative plants could become problems in the future, such as *Lygodium microphyllum* (Old World climbing fern), which is a serious threat throughout south Florida.

Nonnative invasive plants compete with native plants for space, light, water, and nutrients, and make habitat conditions unsuitable the Miami tiger beetle, which responds positively to open conditions. Invasive exotics also affect the characteristics of a fire when it does occur. Historically, pine rocklands had an open, low understory where natural fires remained patchy with low temperature intensity. Dense infestations of *Neyraudia neyraudiana* and *Schinus terebinthifolius* cause higher fire temperatures and longer burning periods. With the presence of invasive nonnative species, it is uncertain how fire, even under a managed situation, will affect habitat conditions or Miami tiger beetles.

Habitat Fragmentation. Management of nonnative invasive plants in pine rocklands in Miami-Dade County is further complicated because the vast majority of pine rocklands are small, fragmented areas bordered by urban development. Fragmentation results in an increased proportion of “edge” habitat, which in turn has a variety of effects, including changes in microclimate and community structure at various distances from the edge (Margules and Pressey 2000, p. 248), altered spatial distribution of fire (greater fire frequency in areas nearer the edge) (Cochrane 2001, pp. 1518–1519), and increased pressure from nonnative invasive plants and animals that may out-compete or disturb native plant populations. Additionally, areas near managed pine rockland that contain nonnative species can act as a seed source of nonnatives allowing them to continue to invade the surrounding pine rockland (Bradley and Gann 1999, p. 13).

In summary, the Miami tiger beetle is threatened by habitat modification and loss, lack of adequate fire management, and vegetation (native and nonnative) encroachment. Habitat loss, while serious, has been partially addressed, especially by the County in cooperation with the Service, State of Florida and other organizations (University of Miami). County land managers are implementing prescribed fire programs and nonnative plant control, which should benefit this species; however, habitat management at all Miami Tiger Beetle sites appears to be failing to prevent the threat of vegetation encroachment into the bare sand areas necessary for the beetle. Habitat loss, conversion, degradation, and fragmentation are expected to continue and increase, affecting any populations on private lands as well as those on protected lands that depend on management actions (i.e., prescribed fire) where these actions could be precluded by surrounding development. With only one known extant population of Miami tiger beetles, the prospective development of the ZMEA represents a significant potential threat to the beetles continued existence.

Overutilization for commercial, recreational, scientific or educational purposes (this section a revision of FWS draft assessment)

Tiger beetles are the subject of more intense collecting and study than any other single beetle group (Knisley and Hill 1992a, p. 9). Interest in the genus *Cicindela* is reflected in a journal entitled ''Cicindela,'' which has been published quarterly since 1969 and is exclusively devoted to the genus. Among the professional researchers and many amateurs that collect tiger beetles are individuals that taken only small numbers but others who take many specimens, often for sale or trade. Information available on the internet and knowledge and communication with many of these collectors suggest sale and trading of specimens has become much more common in recent years. The increased interest and collecting along with photography seems to have been stimulated in part due to the publication of the tiger beetle field guide (Pearson et al. 1997). Although we have no specific information on collecting pressure for the Miami tiger beetle, a market for the similar Highlands tiger beetle, a Federal candidate species, as well as the Florida scrub tiger beetle, does exist, with specimens offered for sale or trade through online insect dealers. In addition, the federally endangered Ohlone tiger beetle (*Cicindela ohlone*) was collected from the type locality after its description in scientific literature (Endangered and Threatened Wildlife and Plants 2001, p. 50347). Considering the recent rediscovery of the Miami tiger beetle and concerns regarding its continued existence, the desirability of this species to private collectors would likely increase, leading to increased collection of specimens.

Due to the species' vulnerability and extreme rarity, collection could be a serious threat, especially if adults are taken prior to oviposition or from small, isolated, or poor-quality sites. It is not possible to assess actual impacts to the population since most occurrences of Miami tiger beetle are not regularly monitored. Access to the USCG and CSTARS sites is gated and accessible only by permit, so collection from these sites is unlikely unless authorized by the property owners. Although periodically patrolled (B. Knisley, pers. comm. 2014), the Zoo Miami site is not gated so there is some potential for the collection of specimens there. Overall, the threat from collection to the Miami tiger beetle is unknown at this time but probably not a significant threat.

Natural enemies. There is no evidence of disease or pathogens affecting tiger beetles although this has not be investigated. Predators and parasites have been found to have significant impacts on adults and larvae. Birds, lizards, and spiders are known to attack adult tiger beetles but robber flies (family Asilidae) are considered to be the most important predators (Pearson et al 2006, p. 183). Knisley and Hill (2010, entire) determined a robber fly accounted for significant predation on the Hairy-necked Tiger Beetle (*Cicindela hirticollis*) at beach site in Maryland. Field observations of The Highlands Tiger Beetle found only a few successful attacks by robber flies (Knisley and Hill 2010, p. 40). However, robber flies are generalist opportunistic predators that feed on a variety of prey and may in most cases have only limited impacts on tiger beetle populations. Although not widely studied, predation of tiger beetle larvae by ants may have important limiting effects, especially on early instars. In one study, ants accounted for 11-17% mortality to larvae of the Highlands Tiger Beetle (Knisley and Hill 2013, p. 37). Another study found ants accounted for some of the reduced survivorship of several species of larvae in Arizona (Knisley and Juliano 1988, p. 1988). The impacts of parasitic tiphiid wasps and bombyliid flies have been commonly found attacking tiger beetle larvae and are probably the most important natural enemies of tiger beetles (Knisley and Schultz 1996, p. 53-57). The wasps enter the larvae burrows, paralyze and lay an egg on the larvae. The resulting parasite larva consumes the host tiger beetle larva. Bombyliid flies (genus Anthrax) drop eggs into larval burrows with the resulting fly larvae consuming the tiger beetle larva. Determining impacts of these parasites and predators is difficult but their presence can commonly be determined by site visits. No robber flies, tiphiid wasps, or bombyliid flies were observed during field studies with the Miami Tiger Beetle, but more extensive surveys are needed to determine if these natural enemies are impacting the species. Various species of ants were commonly seen co-occurring in the sandy patches with adults and larvae of the Miami Tiger Beetle, but their impact, if any could not be determined because of the limited field work with larvae.

Current regulatory mechanisms (from FWS species assessment draft)

<u>The inadequacy of existing regulatory mechanisms</u>. The known extant population of the Miami tiger beetle occurs entirely within the Richmond Pine Rocklands. All remaining Richmond Pine Rocklands occur entirely within the proposed critical habitat boundaries for the Florida leafwing (*Anaea troglodyta floridalis*) and Bartram's scrub-hairstreak (*Strymon acis bartrami*) butterflies, and two pine rockland plants *Brickellia mosieri* (Florida brickell-bush) and *Linum carteri* var. *carteri* (Carter's small flowered flax). The Miami tiger beetle population also co-occurs within known locations for the following federally listed species: *Chamaesyce deltoidea ssp. deltoidea* (deltoid spurge), Florida bonneted bat (*Eumops floridanus*), *Polygala smallii* (tiny polygala), and in the consultation area for the Eastern indigo snake (*Drymarchon corais couperi*), all of which may afford some protection for the beetle. However, regulatory mechanisms currently in effect are not based on the Miami tiger beetle and its habitat, and therefore may not provide adequate protections from threats to beetles or their habitat. The Florida Fish and Wildlife Conservation Commission has not listed the Miami tiger beetle as threatened or endangered, nor are there other State or local regulatory mechanisms in place. Because the beetle is not listed at the State or Federal levels, nothing prohibits collection or importing, exporting, sale, or trade of the species. However, as noted above, access to the USCG and CSTARS sites is gated and inaccessible unless permitted by the property owner. The Zoo Miami site is patrolled but not unreasonable to think that some collection of specimens could occur (B. Knisley, pers. comm. 2014).

Pesticides (modified from the FWS species assessment)

Pesticides may be a potential threat to the Miami tiger beetle, especially during the adult flight period from May through October (Knisley 2011, p. 34). Efforts to control mosquitoes and other insect pests have increased as human activity and population size have increased in south Florida. To control mosquito populations, organophosphate (naled) and pyrethroid (permethrin) adulticides are applied by mosquito control districts throughout south Florida. These compounds have been characterized as being highly toxic to nontarget insects by the U.S. Environmental Protection Agency (2002, p. 32; 2006a, p. 58; 2006b, p. 44). The use of such pesticides (applied using both aerial and ground-based methods) for mosquito control presents a potential risk to the Miami tiger beetle.

The negative effect of insecticides on several tiger beetle tiger beetle species was suggested by Nagano (1982, p. 35) and Stamatov 1972, p. 78), athough this has not been adequately documented. Mosquito control pesticide use within Miami-Dade County pine rockland areas is limited (approximately two to four aerial applications per year since 2010) and the Richmond Pine Rocklands region is not actively treated (Vasquez, pers. comm. 2013). Pesticide drift from mosquito control aerial spray zones to the three known locations of Miami tiger beetles is unlikely based on the considerable distance (estimated minimum distances from spray zone to known Miami tiger beetle populations range from 2-3 km (1.2-1.9 mi)).

Recreational Use

Knisley (2011, entire) reviewed the negative and positive effects of human disturbances on tiger beetles. Vehicles, bicycles and/or human foot traffic have been implicated in the decline and extirpation of tiger beetle populations, especially for species in more open habitats like beaches and sand dunes. The Northeastern Beach Tiger Beetle was extirpated throughout the northeast coincidental with the development of recreational use from pedestrian foot traffic and vehicles (Knisley et al 1987, p.301). The Southeastern Beach Tiger Beetle (*C. d. media*) was extirpated from a large section of Assateague Island National Seashore, Maryland after the initiation of off-highway vehicle use (Knisley and Hill, 1992b). Direct mortality and indirect effects on habitat from OHVs have been found to threaten the survival of the Coral Pink Sand Dunes Tiger Beetle (Gowan and Knisley 2014, p. 127-128). However, there are other documented cases of the beneficial effects of these types of disturbances by creating open areas of habitat for tiger beetles, particularly at sites where vegetation growth has eliminated these open habitat patches (Knisley 2011, p. 44-45). The Ohlone Tiger Beetle has been eliminated from nearly all natural grassland areas in Santa Cruz, California except where pedestrian foot traffic, mountain bike use or cattle grazing has created or maintained trails and open patches of habitat (Knisley and Arnold 2013, p. 578). Similarly, over 20 species of tiger beetles including the Badlands Tiger Beetle at Dugway Proving Ground in Utah are almost exclusively restricted to roads, trails and similar areas kept open by vehicle use or similar human disturbances (Knisley 2011, p. 44-45).

Vehicle activity on roads may have some effect on the Miami Tiger Beetle, but limited field visits indicate this may have minimal effects. Several recent observations at the Metrozoo found a few adults along a little used road and the main gravel road adjacent to interior patches where adults were more common. These adults may have dispersed from their primary interior habitat, possibly due to vegetation encroachment (Knisley 2014, p. 2). Several of the adults at both CSTARS and the Coast Guard site were also found along dirt roads that were not heavily used and apparently provided suitable habitat.

Climate change and sea level. (This section from the FWS Species Assessment).

Climatic changes, including sea level rise (SLR), are major threats to south Florida and could impact the Miami tiger beetle. Our analyses under the Act include consideration of ongoing and projected changes in climate. The terms "climate" and "climate change" are defined by the Intergovernmental Panel on Climate Change (IPCC). The term "climate" refers to the mean and variability of different types of weather conditions over time, with 30 years being a typical period for such measurements, although shorter or longer periods also may be used (IPCC 2007, p. 78). The term "climate change" thus refers to a change in the mean or variability of one or more measures of climate (*e.g.*, temperature or precipitation) that persists for an extended period, typically decades or longer, whether the change is due to natural variability, human activity, or both (IPCC 2007, p. 78).

Scientific measurements spanning several decades demonstrate that changes in climate are occurring, and that the rate of change has been faster since the 1950s. Examples include warming of the global climate system, and substantial increases in precipitation in some regions of the world and decreases in other regions. (For these and other examples, see IPCC 2007, p. 30; and Solomon *et al*. 2007, pp. 35–54, 82–85.)

Scientists use a variety of climate models, which include consideration of natural processes and variability, as well as various scenarios of potential levels and timing of greenhouse gas (GHG) emissions, to evaluate the causes of changes already observed and to project future changes in temperature and other climate conditions (*e.g.*, Meehl *et al*. 2007, entire; Ganguly *et al*. 2009, pp. 11555, 15558; Prinn *et al*. 2011, pp. 527, 529). Although projections of the magnitude and rate of warming differ after about 2030, the overall trajectory of all the projections is one of increased global warming through the end of this century, even for the projections based on scenarios that assume that GHG emissions will stabilize or decline. Thus, there is strong scientific support for projections that warming will continue through the 21st century, and that the magnitude and rate of change will be influenced substantially by the extent of GHG emissions (IPCC 2007, pp. 44–45; Meehl *et al*. 2007, pp. 760–764 and 797–811; Ganguly *et al*. 2009, pp. 15555–15558; Prinn *et al*. 2011, pp. 527, 529).

Various changes in climate may have direct or indirect effects on species. These effects may be positive, neutral, or negative, and they may change over time, depending on the species and other relevant considerations, such as interactions of climate with other variables (*e.g.*, habitat fragmentation) (IPCC 2007, pp. 8–14, 18–19).

The long-term record at Key West shows that sea level rose on average 0.229 cm (0.090 in) annually between 1913 and 2013 (National Oceanographic and Atmospheric Administration (NOAA) 2013, p. 1). This equates to approximately 22.9 cm (9.02 in) over the last 100 years. IPCC (2008, p. 28) emphasized it is very likely that the average rate of SLR during the 21st century will exceed the historical rate. The IPCC Special Report on Emission Scenarios (2000, entire) presented a range of scenarios based on the computed amount of change in the climate system due to various potential amounts of anthropogenic greenhouse gases and aerosols in 2100. Each scenario describes a future world with varying levels of atmospheric pollution leading to corresponding levels of global warming and corresponding levels of SLR. The IPCC

Synthesis Report (2007, entire) provided an integrated view of climate change and presented updated projections of future climate change and related impacts under different scenarios.

Subsequent to the 2007 IPCC Report, the scientific community has continued to model SLR. Recent peer-reviewed publications indicate a movement toward increased acceleration of SLR. Observed SLR rates are already trending along the higher end of the 2007 IPCC estimates, and it is now widely held that SLR will exceed the levels projected by the IPCC (Rahmstorf *et al*. 2012, p. 1; Grinsted *et al*. 2010, p. 470). Taken together, these studies support the use of higher end estimates now prevalent in the scientific literature. Recent studies have estimated global mean SLR of 1.0–2.0 m (3.3–6.6 ft) by 2100 as follows: 0.75–1.90 m (2.5–6.2 ft; Vermeer and Rahmstorf 2009, p. 21530), 0.8–2.0 m (2.6–6.6 ft; Pfeffer *et al.* 2008, p. 1342), 0.9–1.3 m (3.0–4.3 ft; Grinsted *et al.* 2010, pp. 469–470), 0.6–1.6 m (2.0–5.2 ft; Jevrejeva *et al.* 2010, p. 4), and 0.5–1.40 m (1.6–4.6 ft; National Research Council 2012, p. 2).

Other processes expected to be affected by projected warming include temperatures, rainfall (amount, seasonal timing, and distribution), and storms (frequency and intensity) (discussed more specifically under Environmental Stochasticity, below). The Massachusetts Institute of Technology (MIT) modeled several scenarios combining various levels of SLR, temperature change, and precipitation differences with human population growth, policy assumptions, and conservation funding changes (see Alternative Future Landscape Models, below). All of the scenarios, from small climate change shifts to major changes, indicate significant effects on coastal Miami-Dade County.

Prior to inundation, pine rocklands are likely to undergo habitat transitions related to climate change, including changes to hydrology and increasing vulnerability to storm surge. Hydrology has a strong influence on plant distribution in these and other coastal areas (IPCC 2008, p. 57). Such communities typically grade from salt to brackish to freshwater species. From the 1930s to 1950s, increased salinity of coastal waters contributed to the decline of cabbage palm forests in southwest Florida (Williams *et al.* 1999, pp. 2056–2059), expansion of mangroves into adjacent marshes in the Everglades (Ross *et al.* 2000, pp. 101, 111), and loss of pine rockland in the Keys (Ross *et al.* 1994, pp. 144, 151–155). In one Florida Keys pine rockland with an average elevation of 0.89 m (2.9 ft), Ross *et al.* (1994, pp. 149–152) observed an approximately 65 percent reduction in an area occupied by South Florida slash pine over a 70-year period, with pine mortality and subsequent increased proportions of halophytic (salt-loving) plants occurring earlier at the lower elevations. During this same timespan, local sea level had risen by 15.0 cm (6.0 in), and Ross *et al.* (1994, p. 152) found evidence of groundwater and soil water salinization. Extrapolating this situation to pine rocklands on the mainland is not straightforward, but suggests that similar changes to species composition could arise if current projections of SLR occur and freshwater inputs are not sufficient to prevent salinization. Furthermore, Ross *et al.* (2009, pp. 471–478) suggested that interactions between SLR and pulse disturbances (*e.g.*, storm surges) can cause vegetation to change sooner than projected based on sea level alone. Alexander (1953, pp. 133–138) attributed the demise of pinelands on northern Key Largo to salinization of the groundwater in response to SLR. Patterns of human development will also likely be significant factors influencing whether natural communities can move and persist (IPCC 2008, p. 57; USCCSP 2008, pp. 7-6).

The Science and Technology Committee of the Miami-Dade County Climate Change Task Force (Wanless *et al*. 2008, p. 1) recognized that significant SLR is a very real threat to the near future for Miami-Dade County. In a January 2008, statement, the committee warned that sea level is expected to rise at least 0.9–1.5 m (3–5 ft) within this century (Wanless *et al*. 2008, p. 3). With a 0.9–1.2 m (3–4 ft) rise in sea level (above baseline) in Miami-Dade County: "Spring high tides would be at about 6 to 7 feet; freshwater resources would be gone; the Everglades would be inundated on the west side of Miami-Dade County; the barrier islands would be largely inundated; storm surges would be devastating; landfill sites would be exposed to erosion contaminating marine and coastal environments. Freshwater and coastal mangrove wetlands will not keep up with or offset SLR of 2 ft per century or greater. With a 5-ft rise (spring tides at nearly +8 ft), Miami-Dade County will be extremely diminished" (Wanless *et al*. 2008, pp. 3–4).

Drier conditions and increased variability in precipitation associated with climate change are expected to hamper successful regeneration of forests and cause shifts in vegetation types through time (Wear and Greis 2012, p. 39). Although it has not been well studied, existing pine rocklands have probably been affected by reductions in the mean water table. Climate changes are also forecasted to extend fire seasons and the frequency of large fire events throughout the Coastal Plain (Wear and Greis 2012, p. 43). While restoring fire to pine rocklands is essential to the long-term viability of the Miami tiger beetle, increases in the scale, frequency, or severity of wildfires could have negative effects on these beetles considering their general vulnerability due to small population size, restricted range, few colonies, and relative isolation.

<u>Alternative Future Landscape Models.</u> To accommodate the large uncertainty in SLR projections, researchers must estimate effects from a range of scenarios. Various model scenarios developed at MIT and GeoAdaptive Inc. have projected possible trajectories of future transformation of the south Florida landscape by 2060 based upon four main drivers: climate change, shifts in planning approaches and regulations, human population change, and variations in financial resources for conservation (Vargas-Moreno and Flaxman 2010, pp. 1–6). The scenarios do not account for temperature, precipitation, or species habitat shifts due to climate change, and no storm surge effects are considered. The current MIT scenarios range from an increase of 0.09–1.0 m (0.3–3.3 ft) by 2060.

Based on the most recent estimates of SLR and the data available to us at this time, we evaluated potential effects of SLR using the current "high" range MIT scenario as well as comparing elevations of remaining pine rockland fragments and extant occurrences of the Miami tiger beetle. The "high" range (or "worst case") MIT scenario assumes high SLR (1.0 m (3.3 ft) by 2060), low financial resources, a 'business as usual' approach to planning, and a doubling of human population. Based on this scenario, pine rocklands along the coast in central Miami-Dade County would become inundated. The "new" sea level (1.0 meter higher) would come up to the edge of pine rockland fragments at the southern end of Miami-Dade County, translating to partial inundation or, at a minimum, vegetation shifts for these pine rocklands. While sea level under this scenario would not overtake other pine rocklands in urban Miami-Dade County, including the known locations for the Miami tiger beetle, changes in the salinity of the water table and soils would surely cause vegetation shifts. In addition, many existing pine rockland fragments are projected to be developed for housing as the human population grows and adjusts to changing sea levels under this scenario. Actual impacts may be greater or less than anticipated based upon high variability of factors involved (*e.g.*, SLR, human population growth) and assumptions made.

When simply looking at current elevations of pine rockland fragments and occurrences of these plants, it appears that an SLR of 1 m (3.3. ft) will inundate the coastal and southern pine rocklands and cause vegetation shifts largely as described above. SLR of 2 m (6.6 ft) appears to inundate much larger portions of urban Miami-Dade County. The western part of urban Miami-Dade County would also be inundated (barring creation of sea walls or other barriers), creating a virtual island of the Miami Rock Ridge. After a 2-m rise in sea level, approximately 75 percent of the remaining pine rockland would still be above sea level but an unknown percentage of these fragments would be negatively impacted by salinization of the water table and soils, which would be exacerbated due to isolation from mainland fresh water flows. Above 2 m (6.6 ft) of SLR, very little pine rockland would remain, with the vast majority either being inundated or experiencing vegetation shifts.

The climate of southern Florida is driven by a combination of local, regional, and global events, regimes, and oscillations. There are three main "seasons": (1) the wet season, which is hot, rainy, and humid from June through October; (2) the official hurricane season that extends one month beyond the wet season (June 1 through November 30), with peak season being August and September; and (3) the dry season, which is drier and cooler, from November through May. In the dry season, periodic surges of cool and dry continental air masses influence the weather with short-duration rain events followed by long periods of dry weather.

According to the Florida Climate Center, Florida is by far the most vulnerable State in the United States to hurricanes and tropical storms (http://coaps.fsu.edu/climate_center/tropicalweather.shtml). Based on data gathered from 1856 to 2008, Klotzbach and Gray (2009, p. 28) calculated the climatological probabilities for each State being impacted by a hurricane or major hurricane in all years over the 152-year timespan. Of the coastal States analyzed, Florida had the highest climatological probabilities, with a 51 percent probability of a hurricane (Category 1 or 2) and a 21 percent probability of a major hurricane (Category 3 or higher). From 1856 to 2008, Florida actually experienced 109 hurricanes and 36 major hurricanes. Given the single, isolated population of the Miami tiger beetle within locations prone to storm influences, they are at substantial risk from hurricanes, storm surges, and other extreme weather. Depending on the location and intensity of a hurricane or other severe weather event, the beetle is at high risk of extirpation or extinction.

Hurricanes, storm surge, and extreme high tide events are natural events that can pose a threat to the Miami tiger beetle. Hurricanes and tropical storms can modify habitat (e.g., through storm surge) and have the potential to destroy the only known population. Climate change may lead to increased frequency and duration of severe storms (Golladay *et al*. 2004, p. 504; McLaughlin *et al*. 2002, p. 6074; Cook *et al*. 2004, p. 1015). With most of the historical habitat having been destroyed or modified, the one known remaining population of the beetle is at high risk of extirpation due to stochastic events.

Other processes to be affected by climate change, related to environmental stochasticity, include temperatures, rainfall (amount, seasonal timing, and distribution), and storms (frequency and intensity). Temperatures are projected to rise from 2–5 ºC (3.6–9 ºF) for North America by the end of this century (IPCC 2007, pp. 7–9, 13). Based upon modeling, Atlantic hurricane and tropical storm frequencies are expected to decrease (Knutson *et al*. 2008, pp. 1–21). By 2100, there should be a 10–30 percent decrease in hurricane frequency. Hurricane frequency is expected to drop due to more wind shear impeding initial hurricane development. However, hurricane winds are expected to increase by 5–10 percent. This is due to more hurricane energy available for intense hurricanes. In addition to climate change, weather variables are extremely influenced by other natural cycles, such as El Niño Southern Oscillation with a frequency of every 4–7 years, solar cycle (every 11 years), and the Atlantic Multi-decadal Oscillation. All of these cycles influence changes in Floridian weather. The exact magnitude, direction, and distribution of all of these changes at the regional level are difficult to project.

Environmental stochasticity. The Miami Tiger Beetle is likely to be impacted by environmental stochasticity because of its small population size and very limited geographical range. Tiger beetles that have been regularly monitored consistently exhibit extreme fluctuations in population size probably due to climatic or other habitat factors that affect recruitment, population growth and other population parameters. In 20 or more years of monitoring, most populations of the Northeastern Beach and Puritan Tiger Beetles have exhibited 2-5 or more fold differences in abundance (Knisley 2012, entire). Annual populations estimates of the Coral Pink Sand Dunes Tiger Beetle have ranged from less than 600 to nearly 3000 adults over a 22 year period (Gowan and Knisley 2014. p.124). Population viability analyses for these three species determined that stochasticity, specifically the annual fluctuations in population size, was the main factor accounting for the high risk of extinction (Knisley 2006, Gowan and Knisley 2001, 2005).

Small population size, isolation and limited genetic variability. The effect of these factors has not been studied in tiger beetles and only limited relevant information is available. As indicated above, monitoring of some species of tiger beetles (the Northeastern Beach and Puritan Tiger Beetles) for several decades found many populations experience extreme declines in abundance. These studies found some small populations (<50 to 100) adults have persisted over this period of monitoring although dispersal from adjacent populations may have aided in their persistence (Knisley 2012, entire). Several isolated populations of the Highlands Tiger Beetle with less than 50 adults have survived for 20 years (Knisley 2014, in preparation).

Summary (from FWS species assessment)

In summary, the Miami tiger beetle is vulnerable to a wide array of natural and human factors, including problems associated with small fragmented populations, restricted range, pesticides, climate change, and stochastic events. Based on our analysis of the best available information, we have no reason to believe that natural or manmade factors will change in the foreseeable future. Environmental effects resulting from climatic change, including SLR, are expected to become severe in the future and result in additional losses.

Conservation Measures for these Species or their Habitats (unmodified from the FWS draft species assessment)

Miami-Dade County has implemented various conservation measures, such as burning in a mosaic pattern and on a small scale, during prescribed burns in order to help conserve the Miami tiger beetles and other imperiled species and their habitats (Maguire, pers. comm. 2010). Miami-Dade County Parks and Recreation staff has burned several of their conservation lands on a fire return interval of approximately 3 to 7 years. In addition, prescribed burns on large conservation areas, such as parcels within the Richmond Pine Rocklands, have been conducted in a cyclic and systematic pattern, which has provided refugia within or adjacent to treatment areas. As an apparent result, the beetle has retained the remaining local occurrences within their County-managed conservation lands.

Fairchild Tropical Botanic Gardens (FTBG), with the support of various Federal, State, local and nonprofit organizations, has established the "Connect to Protect Network." The objective of this program is to encourage widespread participation of citizens to create corridors of healthy pine rocklands by planting stepping-stone gardens and rights-of-way with native pine rockland species, and restoring isolated pine rockland fragments. By doing this, FTBG hopes to increase the probability that pollinators can find and transport seeds and pollen across developed areas that separate pine rocklands fragments to improve gene flow between fragmented plant populations and increase the likelihood that these species will persist over the long term. Although this project may serve as a valuable component toward the conservation of pine rockland species, it is dependent on continual funding, as well as participation from private landowners, both of which may vary through time.

In 1979, Miami-Dade County enacted the Environmentally Endangered Lands (EEL) Covenant Program, which reduces taxes for private landowners of natural forest communities (NFCs; pine rocklands and tropical hardwood hammocks) who agree not to develop their property and manage it for a period of 10 years, with the option to renew for additional 10-year periods (Service 1999, p. 3-177). Although these temporary conservation easements provide valuable protection for their duration, they are voluntary agreements and not regulatory in nature. Miami-Dade County currently has approximately 59 pine rockland properties enrolled in this program, preserving 69.4 ha (172 ac) of pine rockland habitat (Johnson 2012, pers. comm.). The vast majority of these properties are small—only three are larger than 2 ha (5 ac)—and many are in need of habitat management such as prescribed fire and removal of nonnative invasive plants. Thus, while EEL covenant lands have the potential to provide valuable habitat for the Miami tiger beetle and reduce threats in the near term, the actual effect of these conservation lands is largely determined by whether individual land owners follow prescribed EEL management plans and NFC regulations.

Recommended Conservation Strategies

The current vulnerability of the Miami Tiger Beetle is due primarily to its existence as a single population restricted to a small area that is experiencing habitat deterioration from vegetation encroachment and most recently proposed developments. New and continuation of existing conservation strategies are needed. Implementation of these strategies should be effective in increasing population size and distribution within existing sites and stabilizing the population while additional management is developed.

Immediate Strategies (2015)

1. Reduce vegetation density at Metrozoo to increase the size and connectivity of open patches of sandy soil habitat prior to the start of the May 2015 adult flight season. A controlled burn of the habitat area is apparently planned in the coming months. Alternatively or in addition, localized vegetation reduction of targeted habitat patches can be done by small scale hand removal or the use of the burn box method to increase the size and connectivity of existing patches.
2. Conduct rearing trials using field collected adults to produce larvae so feasibility of translocation to establish populations at new sites can be evaluated.
3. Conduct a thorough resurvey of all three existing sites to determine if new habitat patches exist and if numbers are declining as seems apparent. Record coordinates of all patches, with and without adults, measure and mark with tags for future monitoring.

Other Strategies

1. Survey or resurvey all pine rockland sites in Miami-Dade County.
2. Conduct translocation trials of larvae if rearing larvae is effective and if suitable habitat is available at protected sites.
3. Maintain open patches of existing habitat by hand removal or by using the burn box method to reduce encroaching vegetation and litter.
4. Continue detailed monitoring of adult numbers and habitat patches each year to assess the status of the population and assess fluctuations
5. Create new larger habitat patches using mechanical methods such as scraping of roads where burning or other methods are not feasible.
6. Conduct studies of biology and natural history that benefit management and recovery

TABLES AND FIGURES

TABLES

Table 1. Adult and larval survey results for the Miami Tiger Beetle on all dates at all sites, 2007 through January 2015.

Survey Date	Numbers of Adults Counted per Site: Zoo A+ B	Zoo A	Zoo B	Zoo C	Zoo D	Cstars	CG	Numbers of Larvae at 2 Zoo Sites: A	B
9/7/2007	10	10							
8/22/2008	17	17	ns						
8/23/2008	14	14							
9/7/2008	20	0	20						
9/20/2008	18	ns	15	3					
10/2/2008	16	ns	15	1					
10/17/2008	18	ns	15	3					
4/18/2009	0								
5/15/2009	20	8	12						1 and 2
6/6/2009	23	15	8						
6/20/2009	22	22	ns						
7/18/2009	11	11							
8/18/2009	30	14	16						
9/7/2009	19	2	17						
9/22/2009	12	12	ns				2		
10/18/2009	8	ns	8						
1/15/2010								21	42
5/26/2010	30		30						
8/20/2010	24					38			
8/26/2010							4		
9/30/2010	3								
1/25/2011								0	5
6/1/2011	28								
6/7/2011	12		12						
8/11/2011	42		42						
9/13/2011	17	2	15				2		
10/7/2011	5				7				
1/15/2012									3
6/6/2012	36	0	36						
7/17/2012	36	2	34						
8/30/2012	23	0	15		8				
9/21/2012	4		4						
1/6/2013								0	3
2/5/2013								0	5
5/7/2014	18	0	18						
7/16/2014	14	1	13						
9/10/2014	8		6		2				
9/30/2014							3		
10/14/2014			0			0	0		
1/22/2015								0	15

FIGURES

Figure 1. Representative photos of the Miami Tiger Beetle

Figure 2. Total numbers of adults counted at the Zoo Miami pineland on all survey dates, 2008 to 2014. Totals may be for site A, site B or both sites A and B (see Table 1).

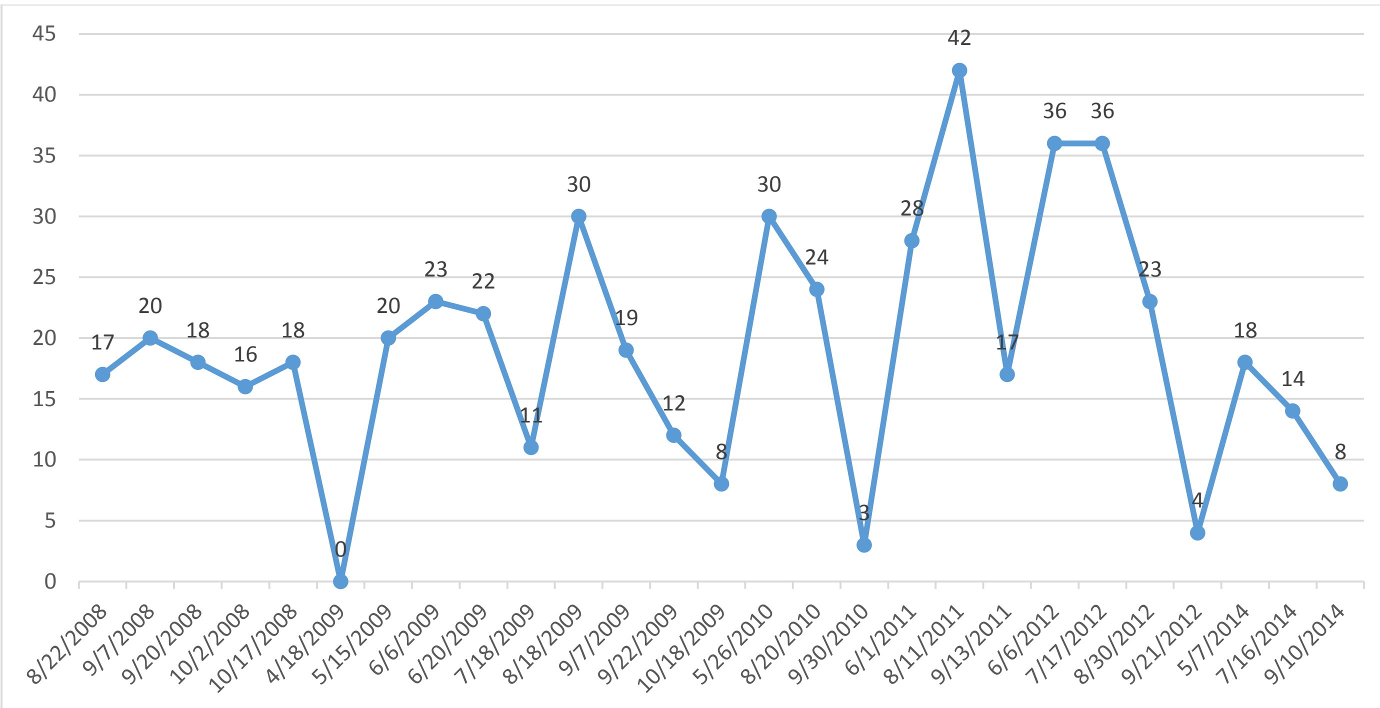

Figure 3. Distribution of pine rockland habitat and sandy soils in Miami-Dade in 1943. Type locality and current location of the Miami Tiger Beetle at Metrozoo is indicated (Map from Dave Almquist, FNAI).

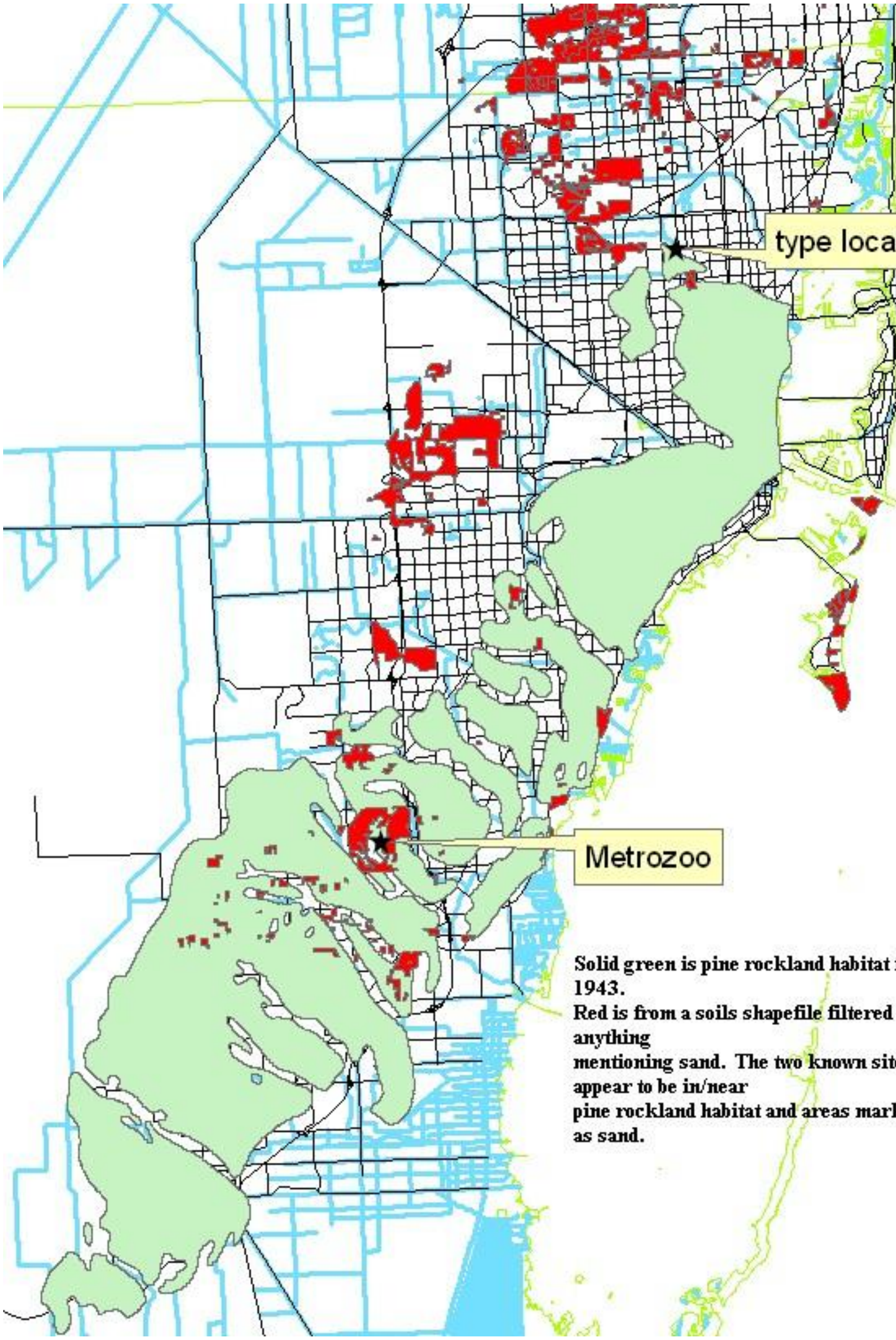

Figure 4. Pine rockland habitat of the Miami Tiger Beetle at Miami MetrozooAA

A

B

Figure 5. Representative microhabitat patches occupied by the Miami Tiger Beetle at the Miami Metrozoo pine rockland.

A B

C

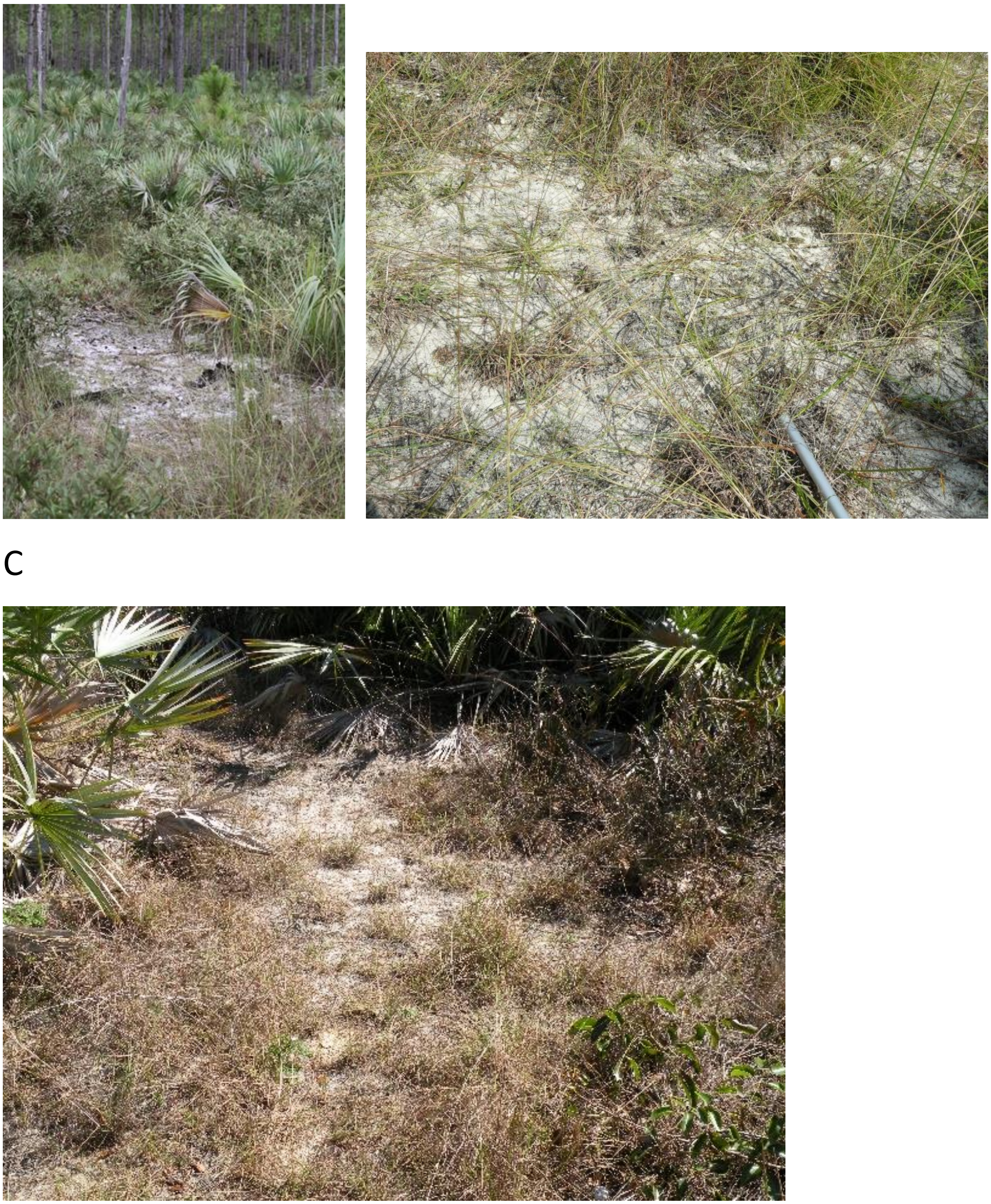

Fig. 6. Aerial photo of the Nixon Smiley pine rockland showing extensive open areas and red dots indicating specific survey points.

Fig. 7. Aerial photo of the Martinez tract adjacent to the Metrozoo with red dots indicating survey points.

Fig. 8. Current distribution of the Miami Tiger Beetles in the Richmond Pine Rocklands with four occupied areas (A,B,C,D) indicated. Adults locations indicated by yellow dots, some of larval patches indicated by red dots. Blue dots show survey patches on 13-15 October 2014 (no adults found).

Figure 9. Photo of an open patch at Metrozoo pine rockland that is marginal or unsuitable habitat for the Miami Tiger Beetle because of encroaching edge plant growth and ground plant cover. B. Photo of previously occupied road at CSTARS now probably unsuitable because of increased vegetation growth

A

B

Figure 10. Photo of the Metrozoo pine rockland showing dates of most recent burns

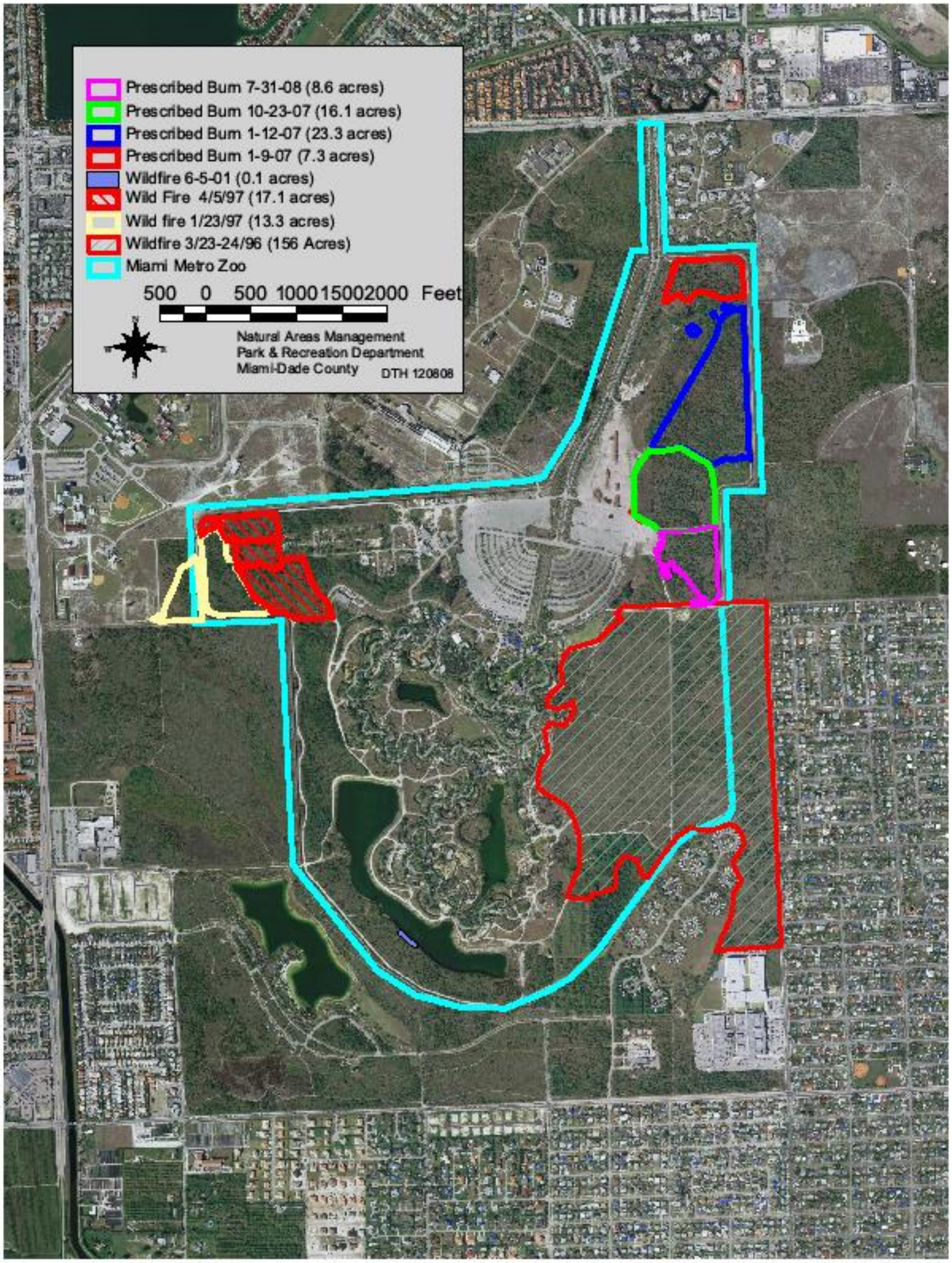

Fig. 11. Photos of Metrozoo pineland area showing results of the November 2014 burn.

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APPENDIX

LIST AND NOTES ON SURVEY SITES (2008-2010). SEE BELOW FOR WAYPOINTS

A. Miami-Dade and Monroe County Sites

1. Monroe County. Everglades, Long Pine Key. 8/23, 9:00-10:30, Wpts. 221-223. Very densely vegetated, high percent of rock substrate, open canopy of 50' pines. No likely habitat here. Also check near Dan Beard research center. Similar non-habitat area

2. Larry and Penny Thompson Park. Borders MetoZoo on south side. 8/23/08, 9/19-20/08, 8/19/10. Multiple surveys throughout much of park, along several trails but little open area seen. Checked several paths and some internal patches around and east of the lake. Sandy patches were present with some potential habitat, but little or no tree canopy cover in most areas. Some of this area has small open sand patches with potential habitat. Resurveyed other areas of park in September 2008 and August 2010 as per Keith Bradley who indicated good nice sandy habitat just S of the park office, between it and 184th and just E of 125th Ave. Also checked sandy areas off of 137th Av. at the W end of the park both north and south of the main park road; other sandy areas throughout the park and the large block south of the main road.

3. Pine Rockland. 8/22, 1:30-2:30. Wpts. 214-216. Open canopy, with low, fairly dense vegetation, high percent of rock substrate with very little sand. Probably unsuitable habitat

4. Goulds. 8/22, 2:45-3:30. Wpts 217-220. Very densely vegetated, high percent of rock substrate, no sand on west side. East side more open with scattered trees, but ground with stones and rock; others sections with solid rock substrate/outcrops with scattered 20-30' pines, some parts grassy. Evidence of recent burn. No likely habitat. 3 photos taken, last showing ground.

More extensive resurvey of all sections on 8/20/10. Access E on 224 from U.S. 1; just S of 224; enter along road, very rocky, rough surface; fairly open but no sand seen; near total rock cover; N side of road very dense, surface with thatch cover and grass over very rock, irregular surface; little pine canopy; fire evident; grade D/F; far SW section with very heavy grass/thatch cover; limited broken ro k, few sandy/gravel patches; cement footers at site, indicating prior devpt plans?, grade D, D-; another section, Bailes Rd. N and S, dense thatch; Bailes near U.S. 1 is tent camp. Another section on 224 w of 120; very open, scattered, small pines; most standing burned trees; irregular rocky cover; much vegetation covering ground with few open patches in interior; delta spurge in some ok patches. Unit 4 is very open and rocky, only burn stumps, heavy thatch and grass; invasive cane; no sand; grade D-F.

5. Navy Wells. 8/23, 11:00. Wpt. 224. Checked along road running through site and some of interior. No apparent interior habitat; some sand piles along road edge placed there and not natural; site has little potential. Resurvey on 9/20/10, nothing new.

6. Deering Estate. 8/23, 1:30. Wpts. 225-229. Checked most of the northern portion of the site where the best potential habitat occurred. Walked all trails in this area and checked edges and some of interior. Trails offered best potential with some dirt, gravel and some sand , but no beetles seen. Very little open in interior areas because of dense vegetation; seemed marginal habitat but should be re-surveyed.

7. Bill Sadowski Preserve. 8/23, 2:00, Wpt 230. Part of site has natural area but is densely vegetated, too high and not suitable. Resurveyed in 2010

8. Ludlam Pineland. Just N of Deering Estate. West side of SW 67th Ave and SW 146th St. Gate at SW 146 and 68th Ave. on N side of site. 8/26, 10:45. Wpts. 261-271.

Gated but open access at SW 69th Av. x SW 147th St. Site included sandy trails and some limited interior sandy patches, has some potential habitat. Resurvey on 8/20/10, (wp 138-145). Access at 138th St.; palmetto and oak understory; gravel road open along powerline, some low eroded section, road unsuitable; other end of site at end of powerline trail is rocky, dense with little or no sand; other trail sections very weedy (invasives?), disturbed; Grade D.

9. Coral Reef Park. SW 152nd St on N side and 80th Av. 8/26, 12:15. Wpt. 272-275. Checked around perimeter and spot interior areas (see waypoints). Most open areas of along western portion with sandy patches among palmetto and pines; seems generally marginal habitat; similar to zoo site but more rocky and fewer sandy patches, but possible resurvey. Evidence of recent burns. Resurveyed on 8/20/10. No new notes.

10. Ned Glen Preserve. W side of SW 87th Ave (Galloway Rd.) , just S of SW 188th St. 8/26, 1:15. Wpt. 276. Walked around and accessed at east section (hopped over fence). Very rocky with pits, rough substrate, very dense vegetation. A large part seemed unsuitable. Also spot check of NE portion along fence where little canopy of scattered pines. Adjacent to school and did not check parts of interior. Probably unsuitable. Resurvey on 8/20. Rocky gravelly, irregular surface, good open patches; most gravel, patchy pines, heavy grass and thatch, not a good site; grade D.

11. Pineshore Pineland Preserve, 8/26, 2:10. Wpts. 277-283. Thorough check of this site with good potential habitat along sandy trails among palmetto and other vegetation. Open patches very sandy and seemingly ok. Generally very similar to zoo site. Resurvey on 8/18/10, (wp 135-137). Access middle of 126 St; good sand along trail, trail disturbed, dense interior; fairly small area of potential habitat, interior patches too small?; side on 128 St. Grade C.

12. Nixon Smiley Preserve, Entrance on SW 128. Few blocks W of SW 137th Av. 8/26, 3:15-4:00. Wpts. 284-290. Access at gate on N? side. Climbed over and walked along trail several hundred meters then further, checking interior on both sides, mostly on left. Very extensive excellent patches of open sand among palmettos, 3-5' oaks, Opuntia and scattered pines; some areas more rocky, evidence of recent? burn. Weather getting stormy so ended survey. Sites is best looking one yet, but apparently near edge of Everglades and previously much more wet (according to Keith Bradley). Resurveyed on 8/21/10 over much of the area. See table and map above.

13. Rockdale Pineland. U, S. 1, S of Rt. 992= 152nd and E side is Hibiscus. Spot survey but appeared to be too densely vegetated and probably unsuitable.

14. NOAA/ Martinez Pineland. Adjacent to Zoo site on southeast side. 9/19. 1:00-2:00, Wpts. 390-399. The sandy roads and several interior patches of this site were checked but no beetles were seen, but survey was limited. Habitat similar to the adjacent zoo site and seems to be potentially suitable.

Resurvey on 8/21/10. Access at SE gate, wp 3. See gps file for notes. Extensive survey, some areas quite rocky and most patches with little sand,; few patches with open sand patches. See Table and map for details

15. Quail Roost. 8/20/10 Ave 147, E side of 200; access at 147 gate, NW boundary; site dominated by tall dense weed, 3' alternate leaved, triangular shape; scattered palmetto, no pine canopy except 1 paaatch; sand patches ok around rocky areas; site seems low, subject to inundation?; grade D.

16. Amelia Earhart Park. 5/26/10. Near Opa-Locka, off 65th x Hy 823. Mostly ball fields and open space, with lake, no scrub evident.

17. Tropical Park. 8/23/10. Near Palmetto Parkway, near SW 82nd Ave. in north Miami. Site suggested by Dave Almquist with some sandy habitat. Survey indicated a very small patch of pine rockland that was very disturbed and very dense. Unsuitable

18. Metro zoo. See above.

19. CStars campus. See above.

20. U. S. Coast Guard. See above.

B. North Miami and Ft. Lauderdale/Broward County

1. County Line Scrub. South side of SW 215 St.(=County Line Rd.), just E of San Simeon Way. Surveyed on 8/26, 9:00 a.m. Site was gated and not accessible; adjacent to commercial buildings with gated parking. Revisit 9/17, 2:00. Wpts 330. Checked open trail around perimeter and limited interior patches. Site seems to have limited potential due to very dense vegetation, heavy vine and vegetation coverage.

2. Dolphin Addition. 8/26, 9:30. Site was gated, could not access. Revisit 9/17, 11:30. Wpts 327-329. Site had limited open sand, along south boundary but better patches on eastern portion. Overall site had much dense vegetation, including heavy Muscatine grape vines and grass/weed coverage . Some ground disturbed. Best potential at wp 328, 329. Probable resurvey, but limited potential?

3. Woodmont. 8/25. Developed site with dense vegetation, paved trails, unsuitable as habitat. done; denser woods, developed, blacktop trails

4. Highlands Scrub—4050 N Dixie Hwy, Pompano Beach Scrub. Bordered by RR; Wpts. 240-242. Near Jct. U.S. 1 and Sample. Also rechecked on 9/18, 5:30, no new wpts. Limited check but best areas as seen in earlier survey were in far northwest section where there are limited areas of open sugar sand. Site with sand pines, palmetto, oaks. Resurvey on 5/28/10. Overall site, fairly dense with some open patches in NW corner along concrete trails. No beetles seen.

5. Helen Klein Pineland Preserve 4701 W. Hillsborough Coconut Creek; only 13 acres; 9/19, 9:00, wpt 379. Brief check of this small developed site with very dense vegetation and no open habitat. Unsuitable

6. Crystal Lake Sand Pine Scrub Natural Area. 8/24 10:00. Wpt. 234-239. Good scrub habitat with several open disturbed sandy areas, but best area is on far side of sites at waypoints 237-237; these have some apparent natural, less disturbed open sugar sand patches. Resurvey on 5/28/10. North area looked more disturbed, south area more natural, but no beetles seen

7. Hillsborough Pineland . 5591 N.W. 74th Place, Coconut Creek. 9/19 developed, pine flatwoods, wetlands.

8. Pine Island Ridge- 3900 SW 100th Ave.Davie. No suitable habitat, only a small sandy trail; pinewoods, horse areas, developed

9. State Park 8/24. Uncertain location. Walked trail to prairie area. Sandy road along prairie edge but not suitable.

10. Cypress Creek Sand Pine Preserve 8/26/10. North side of Cypress Ck. Rd., near Ft. Lauderdale Executive Airport; very little habitat since very dense vegetation throughout with little sand.

11. Gopher Turtle Preserve. 8/26-27/10. Adjacent to Executive Airport, obtained access from Gene Dempsey. Extensive and thorough 2 hour search of this excellent scrub site with deep sand and some good open patches; probably best potential scrub site in area. Found C. hirtilabris but no C. scabrosa or C. floridana. Small carabids like those at zoo site were found. There is record of C. scabrosa collected near here by Mark Deyrup

12. Fern Forest Nature Center. 8/26/10. Area closed but appeared to have no suitable habitat

13. Sawgrass Regional Park, off Sample Rd., near Hy 869. Site a sports park with no habitat.

14. Sugar Sand Park. 8/26/10. Exit 44 off I-95, at Hy 798 x 809. Little suitable habitat, trail through thick scrub is covered with wood chips; few open spots, no beetles

C. Palm Beach County

1. Yamato Scrub. I95 to exit 50 to Congress, left on 82nd; left at Congress/SR807S; left at NW 6th. Survey on 9/18, 9:30, wpts 331-351. Large, well-developed scrub with very good open trails and some interior patches; trails dragged to keep open. Access at northeast end and surveyed main roads and several trails in section north of Clint Moore Rd. Small numbers of *C. hirtilabris* seen around wpt. 334. Large Population of *C. punctulata* seen adjacent to pond on N side of Clint Moore Rd. access. Also checked perimeter road and some trails in south section, south of Clint Moore Rd, wpts 340-351. Some good open trails and interior throughout. Overall, this site seems to have good potential for supporting scrub species. Resurvey on 5/27/2010 by DB; checked various areas within site; found *C. punctulata* and C. hirtilabris but no *C. scabrosa or C. floridana*.

2. Hypoluxo Scrub. 9/18, 1:00; wpts 352-356. Extensive survey of this very open scrub site, along trails and extensive large open patches, especially good potential in south portion. Scattered tall long needle pines, Ceratiola, and 8-20' oaks. Resurveyed on 5/26/10 by DB. Found open sandy areas, apparently disturbed; C. hirtilabris adults present, no others.

3. High Ridge Scrub. 9/18, 2:30, wpts 360-364. Scrub site with very open and much disturbed areas (earlier was a sand quarry) and ridges. Extensive open areas of yellow sand with some gravelly areas (mined?). Overall fairly disturbed, unnatural scrub.

4. Rosemary Scrub, ; I95 N to exit 59, Gateway, right on E. Gateway, left at N. Seacrest; left at Miner Rd. 9/18, 3:45, wpts. 365 (at access). Paved trail through low dense oaks and scattered sand pines; very much grape, dodder type vine. Seemed to be no suitable habitat at this site.

5. Seacrest Scrub, 3400 S. Seacrest Blvd.Boynton Beach. Between 95 and from 95 take Woolbright E to Seacrest, S on Seacrest; on E side of road. Resurvey on 9/18, 4:30, wpts. 366-371. Survey hiking trail through tall long needle pines, grape with dense interior; good natural open patches of sugar sand of very good potential scrub habitat; evidence of recent burning. Re surveyed on 5/27/10; checked sandy trails and open patches; no beetles

6. Palm Beach Pines State Recreation Area. 8/25,4:30. Drove through roads of the site, some sandy roads but mostly low and mesic or hydric habitats. Not suitable.

7. Unnamed scrub. 8/27/10. East of I-95 near Boca Raton airport, bordered by Airport Rd. and I-95. Good open areas along sandy trails; good numbers of C. hirtilabris.

8. Pond Hawk Natural Area. 8/27; Se corner of jct of Hy 809 x 794; very disturbed area; seems sand is being quarried on east end by large pond; other part of area has no habitat.

D. Martin County Sites

1. Jonathan Dickinson State Park, 8/25, 11:00-2:00. Wpts 247-250. This large state park has extensive areas of scrub habitat. Several areas were surveyed including a section in the northeast part of the park at a gated access road entrance. A search along several roads in this area (243-246) revealed little natural open scrub habitat. Much of area was very low scrub with little or no canopy, and possibly unsuitable. Most of the canopy was destroyed by hurricane Andrew. The best area was further north, along the north side of RR tracks on a sandy trail (points 248-250). This area was similar to *highlandensis* and *scabrosa* habitat, but no tiger beetles were seen.

2. Jupiter Ridge Natural Area. 8/25, 2:00. Wpts 253-257. Several areas of good scrub habitat with natural open patches on south side adjacent to fence of Coast Guard facility were surveyed. Numerous larval burrows were seen, mostly 3rd instar *C.hirtilabris* size, some probably 3rd *scutellaris*, others smaller. Dominant vegetation was sand pine, palmetto, Opuntia, gopher apple, oaks. Resurvey on 5/27/10; check of extensive sand areas and very open areas, numerous trails that extend to intercoastal waterway. Site seemed good tiger beetle habitat for C. scutellaris; found C. marginata (near water) and C. hirtilabris, no other species.

3. Hobe Sound NWR. 8/25. 3:30. Wpt 260. Checked several areas adjacent to U.S. 1. Only limited open sandy areas along trails; fairly heavily vegetated; one area with heavy ORV use. Little natural scrub seen and no apparent habitat.

Sites to Survey or Resurvey:

Because the Miami Tiger Beetle is so small, solitary, at apparent low densities and hard to find within the scattered patches of habitat, many of the sites need to be resurveyed to confirm if the MTB is absent. Most important of these would be most of the Miami pine rockland sites, but especially those with considerable open sandy patches, especially Larry and Penny Thompson Park, Nixon Smiley, Pineshore, Ned Glenn, and the Martinez tract.

Waypoints and Coordinates of Survey Sites for Miami Tiger Beetle

Note: Waypoints not taken at some sites, especially where obvious non-habitat

WayPt	UTM	Decimal minutes	Decimal Degrees	Site	Date/Time	
MONROE COUNTY						
221	17 R 534329 2809668	N25 24.208 W80 39.521	N25.40346 W80.65868	Long Pine Key	23-AUG-08 8:06:03AM	95 ft
222	17 R 534115 2808160	N25 23.391 W80 39.651	N25.38985 W80.66085	Long Pine Key	23-AUG-08 8:37:10AM	12 ft
223	17 R 534121 2808188	N25 23.406 W80 39.647	N25.39011 W80.66079	Long Pine Key	23-AUG-08 8:39:01AM	11 ft
MIAMI-DADE						
214	17 R 566094 2835377	N25 38.073 W80 20.496	N25.63454 W80.34160	Pine rockland	22-AUG-08 12:35:46PM	168 ft
215	17 R 566310 2835357	N25 38.061 W80 20.367	N25.63435 W80.33946	Pine rockland	22-AUG-08 12:54:09PM	15 ft
216	17 R 566189 2835138	N25 37.943 W80 20.440	N25.63238 W80.34067	Pine rockland	22-AUG-08 1:05:21PM	53 ft
217	17 R 561601 2826700	N25 33.383 W80 23.205	N25.55639 W80.38676	Goulds	22-AUG-08 1:48:52PM	-7 ft
218	17 R 561692 2826747	N25 33.408 W80 23.151	N25.55680 W80.38585	Goulds	22-AUG-08 1:55:13PM	11 ft
219	17 R 561797 2826719	N25 33.393 W80 23.089	N25.55655 W80.38481	Goulds	22-AUG-08 2:01:52PM	15 ft
220	17 R 561757 2826631	N25 33.346 W80 23.112	N25.55576 W80.38521	Goulds	22-AUG-08 2:08:41PM	11 ft
224	17 R 549788 2813335	N25 26.169 W80 30.291	N25.43614 W80.50485	Navy Wells	23-AUG-08 9:04:03AM	30 ft
225	17 R 569430 2834257	N25 37.457 W80 18.506	N25.62428 W80.30843	Deering Estate	23-AUG-08 12:29:22PM	44 ft
226	17 R 569471 2834351	N25 37.507 W80 18.482	N25.62512 W80.30803	Deering Estate	23-AUG-08 12:32:07PM	6 ft
227	17 R 569480 2834535	N25 37.607 W80 18.475	N25.62678 W80.30792	Deering Estate	23-AUG-08 12:38:21PM	-4 ft
228	17 R 569600 2834743	N25 37.720 W80 18.403	N25.62866 W80.30671	Deering Estate	23-AUG-08 12:47:28PM	-3 ft
229	17 R 569854 2834764	N25 37.730 W80 18.251	N25.62884 W80.30418	Deering Estate	23-AUG-08 12:52:52PM	0 ft
230	17 R 569424 2833188	N25 36.878 W80 18.513	N25.61463 W80.30855	Bill Sawdoski Preserve	23-AUG-08 1:59:29PM	
261	17 R 569763 2835378	N25 38.063 W80 18.303	N25.63438 W80.30506	Ludlam Pineland	26-AUG-08 9:53:04AM	57 ft
262	17 R 569652 2835368	N25 38.058 W80 18.370	N25.63429 W80.30616	Ludlam Pineland	26-AUG-08 9:55:57AM	32 ft
263	17 R 569635 2835341	N25 38.043 W80 18.380	N25.63406 W80.30634	Ludlam Pineland	26-AUG-08 9:58:28AM	15 ft
264	17 R 569444 2835333	N25 38.039 W80 18.494	N25.63399 W80.30824	Ludlam Pineland	26-AUG-08 10:07:52AM	10 ft
265	17 R 569313 2835338	N25 38.042 W80 18.573	N25.63404 W80.30955	Ludlam Pineland	26-AUG-08 10:14:25AM	18 ft
266	17 R 569729 2835328	N25 38.036 W80 18.324	N25.63393 W80.30540	Ludlam Pineland	26-AUG-08 10:31:10AM	17 ft
267	17 R 569815 2835351	N25 38.048 W80 18.272	N25.63414 W80.30454	Ludlam Pineland	26-AUG-08 10:34:48AM	16 ft
268	17 R 569971 2835354	N25 38.049 W80 18.179	N25.63415 W80.30299	Ludlam Pineland	26-AUG-08 10:39:25AM	19 ft
269	17 R 570123 2835334	N25 38.038 W80 18.089	N25.63397 W80.30148	Ludlam Pineland	26-AUG-08 10:43:01AM	16 ft
270	17 R 569827 2835421	N25 38.086 W80 18.265	N25.63477 W80.30442	Ludlam Pineland	26-AUG-08 10:50:34AM	15 ft
271	17 R 569949 2835420	N25 38.085 W80 18.192	N25.63476 W80.30321	Ludlam Pineland	26-AUG-08 10:54:20AM	12 ft
272	17 R 568039 2835042	N25 37.886 W80 19.335	N25.63143 W80.32225	Coral Reef park	26-AUG-08 11:17:34AM	3 ft
273	17 R 568057 2835148	N25 37.943 W80 19.324	N25.63238 W80.32206	Coral Reef park	26-AUG-08 11:21:11AM	-1 ft
274	17 R 567966 2835131	N25 37.934 W80 19.378	N25.63224 W80.32297	Coral Reef park	26-AUG-08 11:24:07AM	-0 ft
275	17 R 567992 2835065	N25 37.898 W80 19.363	N25.63164 W80.32271	Coral Reef park	26-AUG-08 11:30:39AM	15 ft
276	17 R 567063 2830571	N25 35.466 W80 19.932	N25.59110 W80.33220	Ned Glen Preserve	26-AUG-08 12:19:36PM	15 ft
277	17 R 562828 2837065	N25 38.996 W80 22.443	N25.64993 W80.37406	Pineshore pineland	26-AUG-08 1:12:26PM	15 ft
278	17 R 562798 2837097	N25 39.013 W80 22.462	N25.65022 W80.37436	Pineshore pineland	26-AUG-08 1:14:44PM	37 ft
279	17 R 562791 2837124	N25 39.028 W80 22.465	N25.65046 W80.37442	Pineshore pineland	26-AUG-08 1:18:55PM	22 ft
280	17 R 562793 2837134	N25 39.033 W80 22.464	N25.65055 W80.37440	Pineshore pineland	26-AUG-08 1:25:36PM	41 ft
281	17 R 562781 2837189	N25 39.063 W80 22.471	N25.65105 W80.37452	Pineshore pineland	26-AUG-08 1:33:08PM	37 ft
282	17 R 562764 2837183	N25 39.060 W80 22.481	N25.65100 W80.37469	Pineshore pineland	26-AUG-08 1:34:14PM	31 ft
283	17 R 562817 2837157	N25 39.045 W80 22.450	N25.65075 W80.37417	Pineshore pineland	26-AUG-08 1:39:17PM	28 ft
327	17 R 576893 2870473	N25 57.055 W80 13.920		Dolphin Addition		
328	17 R 577158 2870705	N25 57.180 W80 13.760		Dolphin Addition		
329	17 R 577123 2870705	N25 57.179 W80 13.782		Dolphin Addition		
330	17 R 580934 2872941	N25 58.379 W80 11.490		County Line Scrub		
BROWARD						
234	17 R 587764 2906118	N26 16.327 W80 07.262	N26.27212 W80.12103	Crystal Lake Sand Pine	24-AUG-08 9:45:29AM	31 ft
235	17 R 587719 2905986	N26 16.256 W80 07.289	N26.27093 W80.12148	Crystal Lake Sand Pine	24-AUG-08 9:57:51AM	30 ft
236	17 R 587733 2906006	N26 16.267 W80 07.281	N26.27111 W80.12134	Crystal Lake Sand Pine	24-AUG-08 10:00:10AM	33 ft
237	17 R 587735 2905917	N26 16.218 W80 07.280	N26.27031 W80.12133	Crystal Lake Sand Pine	24-AUG-08 10:02:44AM	28 ft
238	17 R 587805 2905909	N26 16.214 W80 07.238	N26.27023 W80.12063	Crystal Lake Sand Pine	24-AUG-08 10:05:20AM	37 ft
239	17 R 587835 2905986	N26 16.255 W80 07.219	N26.27092 W80.12032	Crystal Lake Sand Pine	24-AUG-08 10:06:56AM	39 ft
240	17 R 588961 2907162	N26 16.888 W80 06.538	N26.28147 W80.10896	Highlands Scrub	24-AUG-08 11:20:00AM	30 ft
241	17 R 589027 2907189	N26 16.903 W80 06.498	N26.28171 W80.10830	Highlands Scrub	24-AUG-08 11:24:47AM	15 ft
242	17 R 589107 2907112	N26 16.861 W80 06.450	N26.28101 W80.10751	Highlands Scrub	24-AUG-08 11:30:32AM	7 ft
379	17 R 580897 2911183	N26 19.095 W80 11.369		Helen Klein Pineland		
380	17 R 580035 2911879	N26 19.475 W80 11.884		Hillsborough Pineland		

PALM BEACH						
331	17 R 590276 2921952	N26 24.895 W80 05.686		Yamato Scrub		
332	17 R 590146 2921995	N26 24.919 W80 05.764		Yamato Scrub		
333	17 R 589964 2921797	N26 24.812 W80 05.874		Yamato Scrub		
334	17 R 590089 2921902	N26 24.869 W80 05.798		Yamato Scrub		
335	17 R 590193 2921846	N26 24.838 W80 05.736		Yamato Scrub		
336	17 R 590109 2921668	N26 24.742 W80 05.787		Yamato Scrub		
337	17 R 590067 2921605	N26 24.708 W80 05.813		Yamato Scrub		
338	17 R 589978 2921368	N26 24.580 W80 05.867		Yamato Scrub		
339	17 R 590161 2921573	N26 24.690 W80 05.757		Yamato Scrub		
340	17 R 590252 2921104	N26 24.436 W80 05.703		Yamato Scrub		
341	17 R 590273 2921032	N26 24.397 W80 05.691		Yamato Scrub		
342	17 R 590255 2920897	N26 24.324 W80 05.702		Yamato Scrub		
343	17 R 590269 2920821	N26 24.283 W80 05.694		Yamato Scrub		
344	17 R 590260 2920588	N26 24.156 W80 05.701		Yamato Scrub		
345	17 R 590278 2920518	N26 24.119 W80 05.691		Yamato Scrub		
346	17 R 590468 2920513	N26 24.115 W80 05.576		Yamato Scrub		
347	17 R 590431 2920557	N26 24.139 W80 05.598		Yamato Scrub		
348	17 R 590376 2920590	N26 24.157 W80 05.631		Yamato Scrub		
349	17 R 590486 2920641	N26 24.184 W80 05.565		Yamato Scrub		
350	17 R 590441 2920807	N26 24.274 W80 05.591		Yamato Scrub		
351	17 R 590473 2921028	N26 24.394 W80 05.571		Yamato Scrub		
352	17 R 594027 2939270	N26 34.261 W80 03.353		Hypoluxo Scrub		
353	17 R 593996 2939170	N26 34.207 W80 03.371		Hypoluxo Scrub		
354	17 R 593894 2938989	N26 34.110 W80 03.434		Hypoluxo Scrub		
355	17 R 593970 2938915	N26 34.069 W80 03.388		Hypoluxo Scrub		
356	17 R 593974 2938743	N26 33.976 W80 03.387		Hypoluxo Scrub		
357	17 R 594001 2938627	N26 33.913 W80 03.371		Hypoluxo Scrub		
358	17 R 593869 2938671	N26 33.937 W80 03.450		Hypoluxo Scrub		
359	17 R 593939 2938884	N26 34.053 W80 03.407		Hypoluxo Scrub		
360	17 R 592205 2938831	N26 34.031 W80 04.452		High Ridge		
361	17 R 592319 2938757	N26 33.990 W80 04.383		High Ridge		
362	17 R 592408 2938866	N26 34.049 W80 04.329		High Ridge		
363	17 R 592363 2938968	N26 34.104 W80 04.356		High Ridge		
364	17 R 592184 2938994	N26 34.119 W80 04.464		High Ridge		
365	17 R 592835 2937816	N26 33.479 W80 04.077		Rosemary Scrub		
366	17 R 592648 2930983	N26 29.778 W80 04.219		Seacrest Scrub		
367	17 R 592893 2930920	N26 29.743 W80 04.072		Seacrest Scrub		
368	17 R 592928 2930916	N26 29.740 W80 04.051		Seacrest Scrub		
369	17 R 593004 2930965	N26 29.767 W80 04.005		Seacrest Scrub		
370	17 R 593121 2930948	N26 29.757 W80 03.935		Seacrest Scrub		
371	17 R 593071 2930960	N26 29.764 W80 03.965		Seacrest Scrub		
372	17 R 593030 2930992	N26 29.781 W80 03.990		Seacrest Scrub		
373	17 R 593029 2931008	N26 29.790 W80 03.990		Seacrest Scrub		
374	17 R 593028 2931078	N26 29.828 W80 03.990		Seacrest Scrub		
375	17 R 593007 2931047	N26 29.811 W80 04.003		Seacrest Scrub		
376	17 R 593016 2931119	N26 29.850 W80 03.997		Seacrest Scrub		
377	17 R 592897 2930926	N26 29.746 W80 04.070		Seacrest Scrub		
378	17 R 592895 2930853	N26 29.707 W80 04.071		Seacrest Scrub		
MARTIN						
243	17 R 588141 2989499	N27 01.491 W80 06.687	N27.02485 W80.11144	Johathan Dickson St. Park	25-AUG-08 10:50:40AM	118 ft
244	17 R 588056 2989834	N27 01.673 W80 06.736	N27.02789 W80.11227	Johathan Dickson St. Park	25-AUG-08 10:59:35AM	8 ft
245	17 R 587839 2988911	N27 01.174 W80 06.872	N27.01957 W80.11453	Johathan Dickson St. Park	25-AUG-08 11:34:17AM	18 ft
246	17 R 588259 2989416	N27 01.446 W80 06.616	N27.02410 W80.11026	Johathan Dickson St. Park	25-AUG-08 11:51:10AM	21 ft
247	17 R 587565 2991477	N27 02.565 W80 07.027	N27.04275 W80.11711	Johathan Dickson St. Park	25-AUG-08 12:26:43PM	18 ft
248	17 R 587507 2991538	N27 02.599 W80 07.061	N27.04331 W80.11769	Johathan Dickson St. Park	25-AUG-08 12:30:30PM	14 ft
249	17 R 587473 2991540	N27 02.599 W80 07.082	N27.04332 W80.11803	Johathan Dickson St. Park	25-AUG-08 12:32:37PM	18 ft
250	17 R 587170 2991537	N27 02.599 W80 07.265	N27.04331 W80.12109	Johathan Dickson St. Park	25-AUG-08 12:45:46PM	18 ft
251	17 R 591048 2981568	N26 57.184 W80 04.963	N26.95307 W80.08272	Jupiter Ridge Natural Area	25-AUG-08 1:21:55PM	30 ft
252	17 R 591034 2981572	N26 57.186 W80 04.972	N26.95311 W80.08286	Jupiter Ridge Natural Area	25-AUG-08 1:27:02PM	27 ft
253	17 R 591096 2981383	N26 57.084 W80 04.935	N26.95140 W80.08226	Jupiter Ridge Natural Area	25-AUG-08 1:32:38PM	29 ft
254	17 R 591071 2981367	N26 57.075 W80 04.950	N26.95126 W80.08250	Jupiter Ridge Natural Area	25-AUG-08 1:35:38PM	26 ft
255	17 R 591053 2981347	N26 57.064 W80 04.961	N26.95107 W80.08269	Jupiter Ridge Natural Area	25-AUG-08 1:42:11PM	21 ft
256	17 R 591028 2981324	N26 57.052 W80 04.976	N26.95087 W80.08294	Jupiter Ridge Natural Area	25-AUG-08 1:46:16PM	21 ft
257	17 R 591053 2981291	N26 57.034 W80 04.962	N26.95057 W80.08270	Jupiter Ridge Natural Area	25-AUG-08 1:54:54PM	11 ft
258	17 R 591018 2981208	N26 56.990 W80 04.983	N26.94983 W80.08305	Jupiter Ridge Natural Area	25-AUG-08 2:13:22PM	-1 ft
259	17 R 588147 2990795	N27 02.193 W80 06.677	N27.03656 W80.11129	Hobe Sound NWR	25-AUG-08 3:02:06PM	19 ft
260	17 R 587403 2991860	N27 02.773 W80 07.123	N27.04622 W80.11872	Hobe Sound NWR	25-AUG-08 3:12:24PM	19 ft