FLORIDA KEYS TERRESTRIAL ADAPTATION PROJECT: Florida Keys Case Study on Incorporating Climate Change Considerations into Conservation Planning and Actions for Threatened and Endang...

Logan Benedict
Florida Fish and Wildlife Conservation Commission

Jason M. Evans
Stetson University

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KeysTAP

Florida Keys Case Study on Incorporating Climate Change Considerations into Conservation Planning and Actions for Threatened and Endangered Species

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Florida Keys Case Study on Incorporating Climate Change Considerations into Conservation Planning and Actions for Threatened and Endangered Species

***Project Coordinator**:*

Logan Benedict, Florida Fish and Wildlife Conservation Commission

***Project Team**:*

Bob Glazer, Florida Fish and Wildlife Conservation Commission

Chris Bergh, The Nature Conservancy

Steve Traxler, US Fish and Wildlife Service

Beth Stys, Florida Fish and Wildlife Conservation Commission

Jason Evans, Stetson University

Project Report

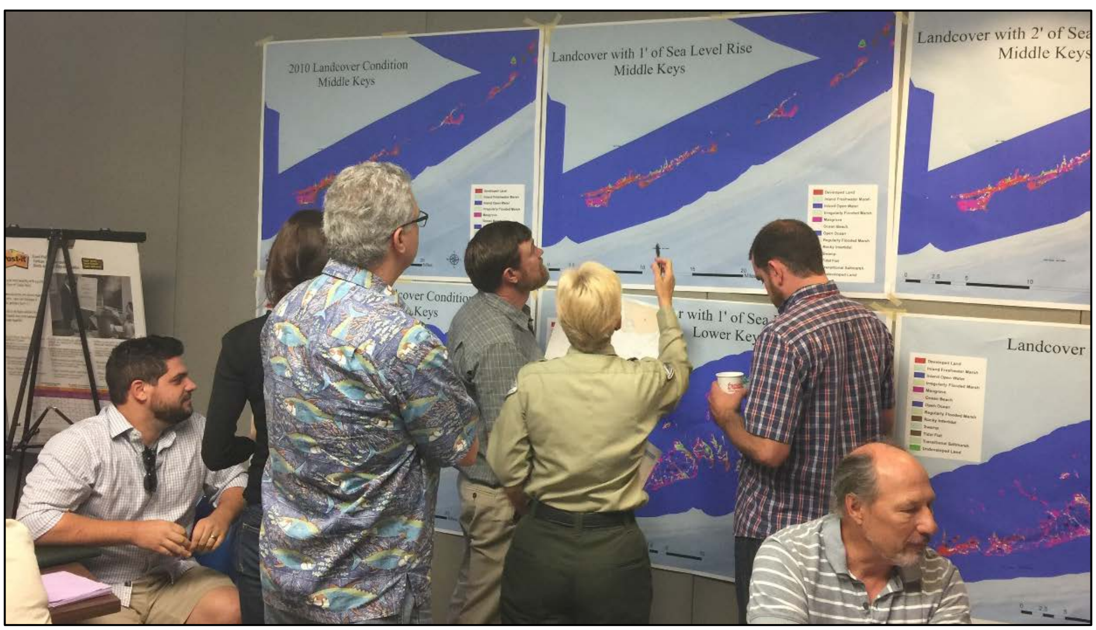

Photo by Logan Benedict

Cover Photo by Ricardo Zambrano

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1. ABSTRACT

"To keep every cog and wheel is the first precaution of intelligent tinkering" _Aldo Leopold

The low-lying Florida Keys are at ground zero for impacts from rising seas. Perhaps the most at-risk natural resources are the endemic terrestrial species with no natural dispersal pathways to suitable habitats outside the Keys. Yet, it is our responsibility as a society to recognize that each species has intrinsic value, and this obliges us to incorporate this ethic into making informed decisions about how best to conserve these species as we confront an uncertain future. The Florida Fish and Wildlife Conservation Commission, U.S. Fish and Wildlife Service, and The Nature Conservancy examined possible in situ and ex situ adaptation strategies to address the vulnerabilities of a suite of 21 federally-listed terrestrial plants and animals at specific sea level rise scenarios (i.e., 1, 2, 3, and 4 ft.). This approach provided the basis for identifying strategies that will increase the adaptive capacity of each species in its native range and builds the map for identifying when we've reached the off-ramps for implementing ex-situ strategies. A series of workshops incorporated the expert opinion of researchers, resource managers, and adaptation experts to create sound and implementable adaptation actions tailored to each species. In concert with this effort, we developed a process to assist managers in decision-making when confronted with climate change or by similar 'wicked' problems. The goal of this stakeholder-based process was to create adaptation strategies that the stakeholder can operationalize into their management plans. As part of this approach, we also examined how to overcome barriers to implementing the strategies, and how to manage for changing conditions.

Definition: Wicked Problem – an issue that is highly resistant to resolution.

2. ACKNOWLEDGEMENTS

This project was supported by the Peninsular Florida Landscape Conservation Cooperative (PFLCC). The Project Team is very grateful for the contribution of the Florida Natural Areas Inventory (FNAI) who provided species-distribution maps, and the University of Florida's McGuire Center for Lepidoptera and Biodiversity. Melissa Benedict and Ricardo Zambrano produced additional maps which were critical to the effective evaluation of several species. We are very appreciative of the work Lily Swanbrow-Becker and Einat Sandbank for assisting with all activities associated with the workshops. This project was supported by US Fish and Wildlife Service cooperative agreement number F16AC01213.

Suggested Citation

Benedict, L., Glazer, B., Traxler, S., Bergh, C. Stys, B., Evans, J. 2018. Florida Keys Case Study on Incorporating Climate Change Considerations into Conservation Planning and Actions for Threatened and Endangered Species. A Project Report for USFWS Cooperative Agreement F16AC01213. 152 p.

3. EXECUTIVE SUMMARY

This project focused on climate adaptation planning for federally endangered terrestrial species in the Florida Keys. The Florida Keys are among the most vulnerable areas to the effects of sea level rise in the US due to their low-lying elevation. This vulnerability puts the over 30 federally listed species that occupy the Keys, especially those that occur nowhere else, at a greater risk of extinction.

We discovered that in many cases there is enough information and expert knowledge to make robust adaptation decisions. Only a small number of species were so knowledge-poor that we were unable to fully identify the consequences of climate change on their abilities to persist. We also determined that non-climate stressors (e.g., pollution, invasive species including predators, and loss of habitat from coastal development) may be as consequential or more important than climate-based stressors, at least in the short term.

KEY FINDINGS**:**

Most project species will lose 90% or more of their current range in a 2ft of sea level rise scenario. This is especially true of plants and species that occupy the lower and middle Keys. Without interventions these species will be lost to extinction.

Feral cats pose a more immediate threat for small mammals and ground-nesting birds in the Florida Keys than climate change. Measures must be taken to reduce feral and outdoor cat populations, or endemic species will face extinction before sea level rise becomes a more immediate threat. Furthermore, rising sea levels will further contract species ranges pushing them closer to human habitation and thus likely increasing feral and outdoor cat interactions.

For many species there are no good long-term solutions for survival within the Florida Keys. For these species, ex-situ options may be the only solution for their long-term survival. Suggested ex-situ options included species survival plans within zoos and botanical gardens, relocation to higher elevation within the Keys, relocation to the mainland Florida, or relocation to areas outside the U.S.

PROPOSED ACTIONS:

Moving species to higher elevations within the Keys to reduce the threat to rising seas. This work is already being implemented for the Keys tree cactus within its historic range in the Keys. Sessile species will respond best to this action. Additionally, elevating habitats will serve the same function and may provide refuge from rising seas. For example, for the roseate tern, nesting platforms can be raised well above rising seas. For butterflies, host plants and wildflowers can be moved to higher elevations throughout the Keys.

Captive husbandry in zoos and botanical gardens. This strategy was considered for a number of species. The Florida Key deer is a prime candidate for captive populations in zoological institutions. This species is highly adaptable and has public interest and could persist in captivity while educating zoo visitors about the plight of the Florida Keys and climate change.

Allow planting of endangered species in private gardens and landscapes. In recent years, planting native landscapes on private lands has increased in popularity. Planting endangered plants or host plants of endangered butterflies within Keys landscapes may help bolster their populations and provide assurance populations throughout the Keys. This action was proposed for species like the Big Pine partridge pea and pineland croton, the host plant of the Bartram's hairstreak. Both species exist in pine rocklands within the Keys.

Elevate habitat alongside human development to meet the rate of sea level rise. As sea levels rise, humans will either need to elevate their infrastructure or abandon it. Raising infrastructure may provide natural resource managers with a unique opportunity to raise fragments of habitats as well. Elevating freshwater resources would be critical for the long-term survival of many terrestrial species in the Keys. Considering the importance of freshwater in the Keys, this action will potentially help all terrestrial animals. Endangered plants may benefit if they are planted among these newly raised areas.

Assisted migration outside of the Florida Keys. Understanding that long term survival in the Keys is unlikely for threatened and endangered species, establishing assurance populations outside of the Keys may be their only hope. Since there are no natural corridors for terrestrial species to leave the Keys, this would require direct human intervention. Participants believed that The Lower Keys marsh rabbit could be moved into national wildlife refuges or state parks within Florida's mainland. These habitats would be better insulated from the threat of sea level rise but might face new threats from predators or hybridization with mainland marsh rabbits.

Gene banking is a no-regrets approach. Cataloging the genetic profile of at-risk species is a low-cost way to ensure that the genetic capital associated with species diversity is not lost. All species should have their genes conserved.

Allowing for extinction. This option was considered only in the most extreme cases where no reasonable alternative was possible. No species in this study was proposed under this option; however, the Florida Semaphore cactus was discussed in this context based upon its unique biology: sexual reproduction no longer occurs in the species. In this instance inaction becomes the selected action. This option raises ethical issues that ultimately rely on societal values.

LESSONS LEARNED:

Models have limitations. Experienced managers are needed to interpret the models and to use them to contextualize adaptation options. Those planning for climate change may suggest newer or more detailed maps are necessary to make decisions. However, models will always have limitations and are only valuable to frame discussions rather than to generate solutions.

Removing time-to-an-event occurring provides for a more focused discussion. Focusing on a specific event occurring rather than the time to that event reduces the baggage associated with the time-consuming discussions associated with when the event will occur. Because we know that sea level rise is inevitable in the Florida Keys, the discussions avoided focusing on when the event will occur and went directly to how to adapt to the event itself.

Priorities must be established based on social and economic values. Resources will always be prioritized for species at greater risk or those that are more socially or economically valuable.

Risks must be assessed to reduce vulnerabilities. Risks have multiple dimensions including the risks associated with both action and inaction. Each of these should be assessed on a species by species basis, or based on species with shared vulnerabilities. Adaptation planning requires understanding the species-specific risk profiles and tailoring responses based on those profiles.

Species management as it pertains to climate adaptation is by design an ongoing process requiring periodic revisiting, revising, and refining. Approaches that may be available under 1-m of sea level rise may not be an option under 2-ft of sea level rise. Therefore, adaptation should be viewed as an ongoing activity and be assessed on a regular basis.

To truly be adaptive requires a flexible approach to management at all levels. For example, those planning for adaptation must recognized that funding sources often by design focus on very specific deliverables which, in an adaptive environment, is often not realistic. Granting agencies and foundations should be accommodating to changing conditions.

Representatives of multiple disciplines that focus on social, economic, and ethical values must be at the table to ensure that adaptation options are suitable for multiple organizations and sectors thereby increasing the likelihood of successful outcomes. Climate change adaptation has potential impacts on many sectors and adaptation for natural resources may be a lower social priority (e.g., when compared with human health). In urban environments, for example, representatives from natural resource agencies or organizations should consider partnerships with other sectors who are dealing with similar threats to develop multi-dimensional adaptation strategies. For example, designs that achieve solutions for housing could include components that provide natural resource services for species at risk.

Implementation is difficult, and ways must be found to overcome barriers that impede implementing adaptation strategies. Although implementation was not a focus of this project, the project team understood that perhaps the most difficult part of adaptation, especially in the Climate-Smart context, is the implementation phase.

Natural resources managers face many barriers to implementing climate adaptation actions. While natural resource managers may be able to tackle some of these barriers within their own agencies or managed lands, others will require local stakeholder buy in, large societal changes, or even changes in federal, state and/or local laws and/or policies.

There is a need to compile case studies and build information networks to share methodologies to overcoming barriers and lessons learned. As climate adaptation actions are successfully implemented, both successes and failures must be shared with the wildlife conservation community.

We believe many of these take home messages are broadly applicable to natural resource adaptation under a changing climate. Whereas this project looked specifically at a suite of Florida Keys species, the lessons from this project are applicable to other locations within which species and their associated habitats are at risk from changing conditions.

4. INTRODUCTION

The earth's climate is changing. That is irrefutable. The changing climate has already resulted in altered precipitation patterns, warming temperatures, and changes to the ocean's chemistry. In turn, this has led to rising sea levels (SLR), saltwater intrusion into groundwater, and habitat conversions (e.g., salt marsh to mangroves) (Dubois et al. 2011, Geselbracht et al. 2011, Osland et al. 2015, Rabe and Stumpf 2015).

Wildlife species and the habitats they occupy are highly vulnerable to these changing conditions. Their vulnerabilities are magnified substantially when coupled with additional anthropogenic and naturally occurring stressors, including, for example, those associated with habitat loss from urbanization, altered fire regimes, and invasive species. How ecosystems change, and how the associated species respond, will ultimately determine if species persist or become extinct (Dangendorf et al. 2017, Thomas et al. 2004).

In many cases, species are not able to adapt on their own due to the rapid changes they are encountering including roadblocks to their successful migration and therefore range expansion/relocation, as well as the changes in the extent and structure of the habitat they occupy. For example, the pine rockland community of Big Pine Key which supports a number of listed endemic species, was 1,049 hectares in 1955; in 1989 the extent had been reduced to 701 hectares (Folk et al, 1991). In cases in which species are unable to adapt on their own, management interventions are necessary to support their long-term survival.

Designated conservation lands provide strongholds for many rare and threatened species, and for some those places may be their last refuge. In many cases, these lands and their managers are the last best hope for the conservation of these species. However, given the changes occurring even on these protected lands, management practices must adapt to changes if the at-risk species are to persist over the long term. The IPCC (2001a) defines adaptation as an adjustment in natural or human systems in response to actual or expected climatic stimuli or their effects, which moderates harm or exploits beneficial opportunities. The impacts of climate change imply that conservation managers must also be prepared to change their management strategies to optimize conservation of target species. How managers respond to these vicissitudes is one of the more daunting challenges they face.

Adaptation planning has become a valuable tool to achieve the goal of conserving at-risk species. Climate smart adaptation (Stein et al. 2014) contextualizes this approach into a series of steps which are designed to ensure that the correct questions are addressed, insightful options are developed, and actions are taken. To accomplish this, planning is broken down into a series of steps. Many steps also require looking back to former decisions, where managers or planners may need to revisit or reassess the information in a former stage in the cycle. FWC has built on this concept by identifying intervention points for different groups (i.e., scientists and managers) and placed a heavy emphasis on monitoring to understand when triggerpoints for adaptation actions are achieved (Glazer 2013, Vargas Moreno et al. 2013) (Figure 1). This approach provides a framework for tying science and management together to achieve conservation goals that apply adaptation to attain their objectives.

> Definition: Trigger Point - A circumstance or situation that causes an event to occur.

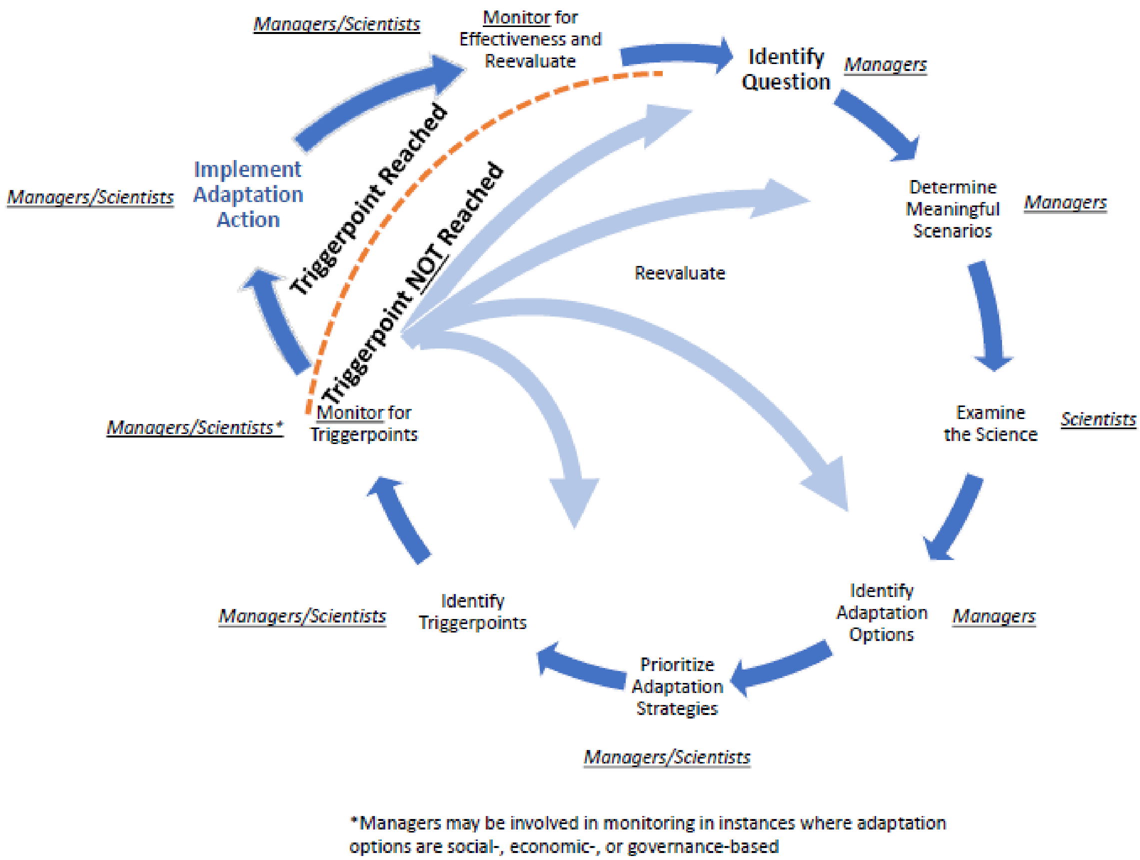


Figure 1. The FWC KeysMAP process for climate adaptation planning. The approach identifies the roles of managers and scientists in the process of identifying priorities and desired outcomes. This approach places an emphasis on identifying triggerpoints for adaptation and developing monitoring programs to identify when triggerpoints are reached and uses scenario planning as a tool.

Adaptation strategies have been commonly developed for national or regional scales. However, to create meaningful and implementable actions, adaptation strategies should be downscaled to the local scale (Shaw et al. 2009). For example, the *National Fish, Wildlife, and Plants Climate Adaptation Strategy* (NFWPCAS: http://wildlifeadaptationstrategy.gov) was purposefully calibrated at national and regional levels, although the plan recognizes that successful adaptation needs to be more locally targeted.

The Florida Keys are among the most vulnerable areas to the effects of sea level rise in the US (Hoegh-Guldberg 2010) due to their low-lying elevation. This vulnerability puts the species that occupy the Keys, especially those that occur nowhere else, at a greater risk of extinction. Over 30 federally listed threatened and endangered, candidate, and at-risk species occur throughout the Florida Keys. It is projected that by 2100, many of them will be extinct or on the brink of extinction (The Nature Conservancy 2009). With the imminent threat of rising seas, many in the conservation community have raised a call for action (Dubois et al. 2011, Hoegh-Guldberg 2010, Ross et al. 1994, Reece et al. 2013, Southeast Florida Regional Climate Compact 2012, The Nature Conservancy 2009).

A systematic look at the species and their habitats and threats in the Florida Keys provides guidance for prioritizing financial resources and localized actions (e.g. KeysMAP, the Monroe County Climate Action Plan, the Monroe County Sustainability Action Plan, and the Energy and Climate section of the Monroe County Comprehensive Plan). These efforts build on resources such as outputs from models (e.g., Sea Level Affecting Marshes Model [SLAMM]). By using the models in targeted and relevant approaches, scenarios can be developed which can, for instance, provide spatial representations of expected changes to habitats. This allows for a clearer perspective on potential changes to the environment, and where impacts may first occur. Unfortunately, because the Florida Keys are so low-lying, most habitat succession models that account for sea level rise resolve to the nearly complete loss of all terrestrial habitats. Therefore, because upland habitats are limited, resource managers and policy-makers must face the challenge of conserving species within their historic ranges. However, other more radical approaches must be considered if a full suite of options is to be considered. These may include such ex-situ approaches as translocating individuals or populations into locations where they do not currently occur or gene banking.

> Adaptation approaches: There are several pathways to reducing the risk of impacts to species or habitats due to climate change. These approaches differ based upon the situation, or the goal of those implementing the adaption. Listed below are a few general approaches to climate adaption.
>
> 1. Sustain fundamental ecological functions
> 2. Reduce the impact of existing biological stressors
> 3. Maintain or create refugia
> 4. Maintain and enhance species and structural diversity
> 5. Increase ecosystem redundancy across the landscape
> 6. Promote landscape connectivity

Effective management of terrestrial species in the Florida Keys is made more complex by the mosaic of jurisdictions. To better facilitate successful development of adaptation strategies, local agencies, non-governmental organizations, and research institutions, and other stakeholders need to be engaged early, and contribute to the development of all steps of adaptation planning. The Florida Keys contains conservation lands managed by the US Fish and Wildlife Service, National Park Service, Florida State Parks, Florida Fish and Wildlife Conservation Commission, the U.S. Navy, Monroe County, and local municipal governments as well as non-governmental organizations such The Nature Conservancy, various land trusts, and a host of other nongovernmental conservation organizations. Including key representatives from relevant organizations ensures a diversity of perspectives and provides a framework for how each organization can contribute to the execution of identified actions. Given this complexity, those charged with the management of protected species must work across jurisdictional boundaries to ensure their goals are achieved.

This project identified vulnerabilities and adaptation options for a suite of 21 terrestrial plant and animal species endemic to the Florida Keys that are federally threatened or endangered. The species' vulnerabilities to 1-ft, 2-ft, 3-ft, and 4-ft of sea level rise were examined. To accomplish this, we examined each species exposure to rising seas based on their current distribution and habitat associations and the projected changes to those habitats. We utilized SLAMM habitat modeling to predict how habitats may change under the sea level rise scenarios. This approach provided a mechanism to determine what species were most at risk under different SLR scenarios, and further provided a way to prioritize adaptation actions on a species by species basis. Furthermore, it was our intention that this project serves as case study for developing adaptation strategies and that this approach be applicable outside of the project areas where managers are facing similar issues. Rather than talking about adaptation in the abstract, we sought to provide real context with individual species and proposed sea level rise impact scenarios. We developed a full range of adaptation options which included examining possible actions and risks involved including cost, possible maladaptation associated with each action, and the complexity of implementation.

Definition: Maladaptation - Any changes in natural or human systems that inadvertently increase vulnerability to climatic stimuli; an adaptation that fails in reducing vulnerability but increases it instead (IPCC TAR, 2001).

We addressed four broad themes in this project: 1) evaluating potential impacts to individual federally-listed species under the different SLR scenarios, 2) developing adaptation strategies to address the species' vulnerability to sea level rise, 3) prioritizing those adaptation options, and 4) evaluating the risks of action and inaction. We utilized a stakeholder-based approach for developing adaptation strategies.

This report details 1) technical information about the species at risk from climate change, 2) adaptation options recommended by the group of experts for each species, and 3) triggerpoints which identify when to implement a strategy. Secondarily, we examined monitoring programs with respect to recognizing when triggerpoints are achieved as well as identifying research needs. We also provide a targeted conversation about adaptation and the culture of conservation for managers, the science community, and the public. These types of conversations are becoming increasingly more common and the resulting information is beginning to be incorporated into management decisions. The conservation community is accustomed to responding to crises after they have happened, and previously these types of adaptation discussions have taken the form of the post mortem or after-action reports. The goal of this project was to holistically look at the Florida Keys and develop localized, on-the-ground adaptation strategies that may be used by managers to make better-informed, proactive decisions, while also outlining the risks involved to help make tough decisions.

5. PROJECT PHASE I: CLIMATE ADAPTATION CONSIDERATIONS

5.1 PROJECT OBJECTIVES

Objective 1: Using scenarios and other best available science to develop climate change adaptation strategies and actions for the terrestrial federally threatened and endangered species throughout the Florida Keys for agencies and non-governmental organizations to consider in their immediate and long-range planning efforts.

Objective 2: To develop a robust decision framework for the adaptation strategies.

5.2 METHODS

Florida Fish and Wildlife Conservation Commission began its exploration into impacts of climate change on Florida's wildlife in 2008, when it held a climate adaptation summit. Since the summit, FWC has worked to better understand the vulnerability of Florida's species to a variety of climate change factors (i.e. sea level rise, temperature shifts, and rainfall shifts). In the last 5 years, FWC has shifted to stakeholder-based scenario planning projects, aimed at understanding future impacts to species and natural resources. The first of these projects were employed in the Keys and south Florida estuarine/marine ecosystem in KeysMAP 1 and 2 (Glazer 2013, Vargas Moreno et al. 2013). This project focused on strategy development and setting management priorities. FWC has built on this concept by identifying intervention points for different groups (i.e., scientists and managers) and placed a heavy emphasis on monitoring to understand when triggerpoints for adaptation actions are achieved (Figure 1). Following these efforts, a project in the Big Bend region of Florida (Benedict et al. 2016) worked elicited the input of state and federal resource managers to develop climate adaptation strategies on local and regional scales. This project also provided first steps toward the implementation of climate adaptation strategies generated and prioritized by and for natural resource managers.

Building upon all previous work, this project was designed to examine the potential vulnerabilities of terrestrial federal T&E species in the Florida Keys under different sea levels, and to find actionable solutions for sustaining their populations. The project also aimed to provide Florida Keys resource managers with the tools to incorporate adaptation strategies into their plans and make tough decisions in the face of rising sea levels. Our approach was workshop-based, with each workshop focusing on a specific audience and step in the adaptation planning process. To achieve this, stakeholders and scientists worked together in small group activities, brainstorming consequences of scenarios and developing adaptation options under alternative future scenarios related to SLR projections.

5.2.1 INITIAL PLANNING PERIOD

As a first step, the project management team identified focal species and subspecies to be examined. The selection process ultimately resulted in focusing on only the terrestrial federal threatened and endangered (T&E) floral and faunal species in the Keys. Those that are endemic to the Keys, or that rely on the Keys for the completion of their reproductive cycle were given preference over more transient species. To avoid repeating recent efforts (KeysMAP 1 & 2), marine species were not included in this project.

Table 1. The 21 species and subspecies in the Florida Keys examined for vulnerabilities under sea level rise scenarios and for which adaptation options were developed Species are listed by their taxa, and their current federal designation for protection (E=Endangered; T=Threatened).

TAXA	Common Name	Scientific Name	Federal Status
Mammals	Key deer	*Odocoileus virginianus clavium*	E
	Key Largo cotton mouse	*Peromyscus gossypinus allapaticola*	E
	Key Largo woodrat	*Neotoma floridana smalli*	E
	Lower Keys marsh rabbit	*Sylvilagus palustris hefneri*	E
	Rice rat	*Oryzomys palustris natator*	E
Birds	Roseate tern	*Sterna dougallii*	T
Reptiles	American crocodile	*Crocodylus acutus*	T
	Eastern indigo snake	*Drymarchon corais couperi*	T
Invertebrates	Bartram's hairstreak butterfly	*Strymon acis bartrami*	E
	Florida leafwing butterfly	*Anaea troglodyta floridalis*	E
	Miami blue butterfly	*Cyclargus (Hemiargus) thomasi bethunebakeri*	E
	Schaus swallowtail butterfly	*Heraclides aristodemus ponceanus*	E
	Stock Island tree snail	*Orthalicus reses (not incl. nesodryas)*	T
Plants	Big Pine partridge pea	*Chamaecrista lineata keyensis*	E

	Blodgett's silverbush	*Argythamnia blodgettii*	T
	Cape Sable thoroughwort	*Chromolaena frustrata*	E
	Florida semaphore cactus	*Consolea corallicola*	E
	Garber's spurge	*Chamaesyce garberi*	T
	Key tree-cactus	*Pilosocereus robinii*	E
	Sand flax	*Linum arenicola*	E
	Wedge spurge	*Chamaesyce deltoidea serpyllum*	E

In October 2016, an initial stakeholder meeting was held at the Marathon Government Center in Marathon, Florida. This meeting was designed to introduce the project and the list of selected focal species and subspecies to local resource managers and planners, provide background information related to climate change in the Keys, and review the project's goals and timeline. A list of participants for this meeting and each workshop can be found in Appendix 1.

Following the initial stakeholder meeting, we compiled spatially-explicit species distribution data to develop range maps for each species and subspecies (see Figure 2 for an example) from a variety of sources including the Florida Natural Areas Inventory (FNAI), The Florida Museum of Natural History, and by consulting individual species experts. Unfortunately, no distribution data exists for the Florida leafwing because the Keys population no longer persists. Nevertheless, the leafwing remained a project species for the sake of discussion.

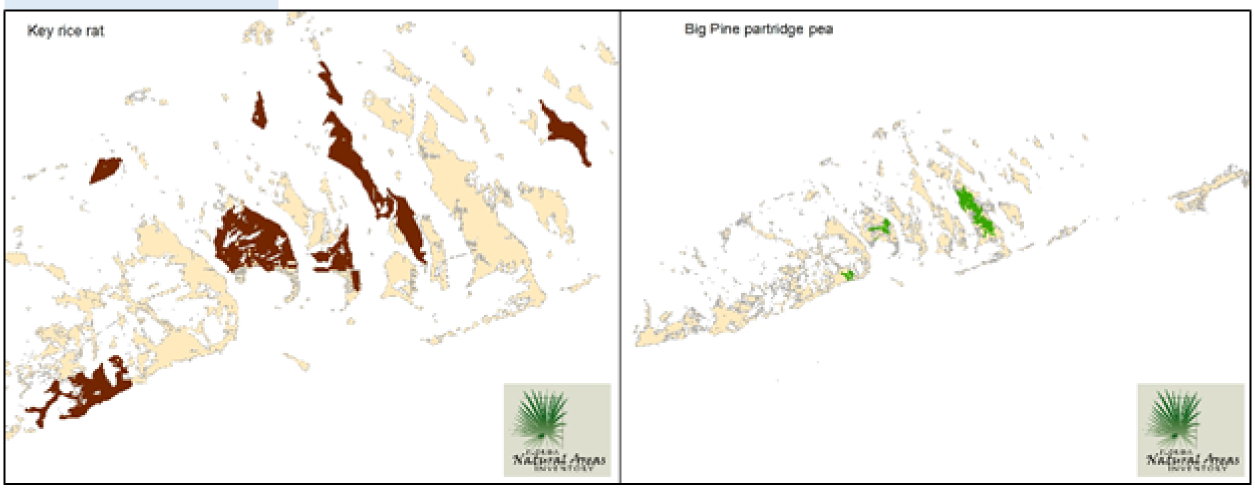


Figure 2. Species Distribution Maps. This figure illustrates the current known distribution of two of the project species. The map on the left illustrates the current known distribution of the Keys rice rat. The map on the right

illustrates the current known distribution of the Big Pine partridge pea. Both maps in this figure were provided by the Florida Natural Areas Inventory (2017).

To validate the species distributions, we conducted a webinar with a group of researchers and biologists who were most familiar with the focal species. Webinar participants were asked to identify data gaps, and point out sites that were no longer occupied. Their comments were incorporated into information used in Workshop 1.

5.2.2 THE SCENARIOS – SEA LEVEL RISE THRESHOLDS

To examine the effects of sea level rise on habitats, Dr. Jason Evans of Stetson University constructed a set of Sea Level Affecting Marshes Model (SLAMM)-based maps for the entire project region (see Figure 3a for the Marathon area under current conditions and Figure 3b under 4-ft of SLR). The SLAMM outputs were mapped to show how the current vegetative communities are expected to shift either in terms of extent or species composition from current conditions as a result of 1’, 2’, 3’, and 4’ of sea level rise. This rules-based model incorporates variables such as erosion, accretion, saturation, salinity, and inundation to model future conditions. Each map was printed at a large scale to provide workshop participants a readily accessible view of the potential changes that might take place across the study area. These maps were displayed during all workshops throughout the project to aid participants in assessing each scenario’s impacts on each species. A full list of maps can be found in Appendix 2.

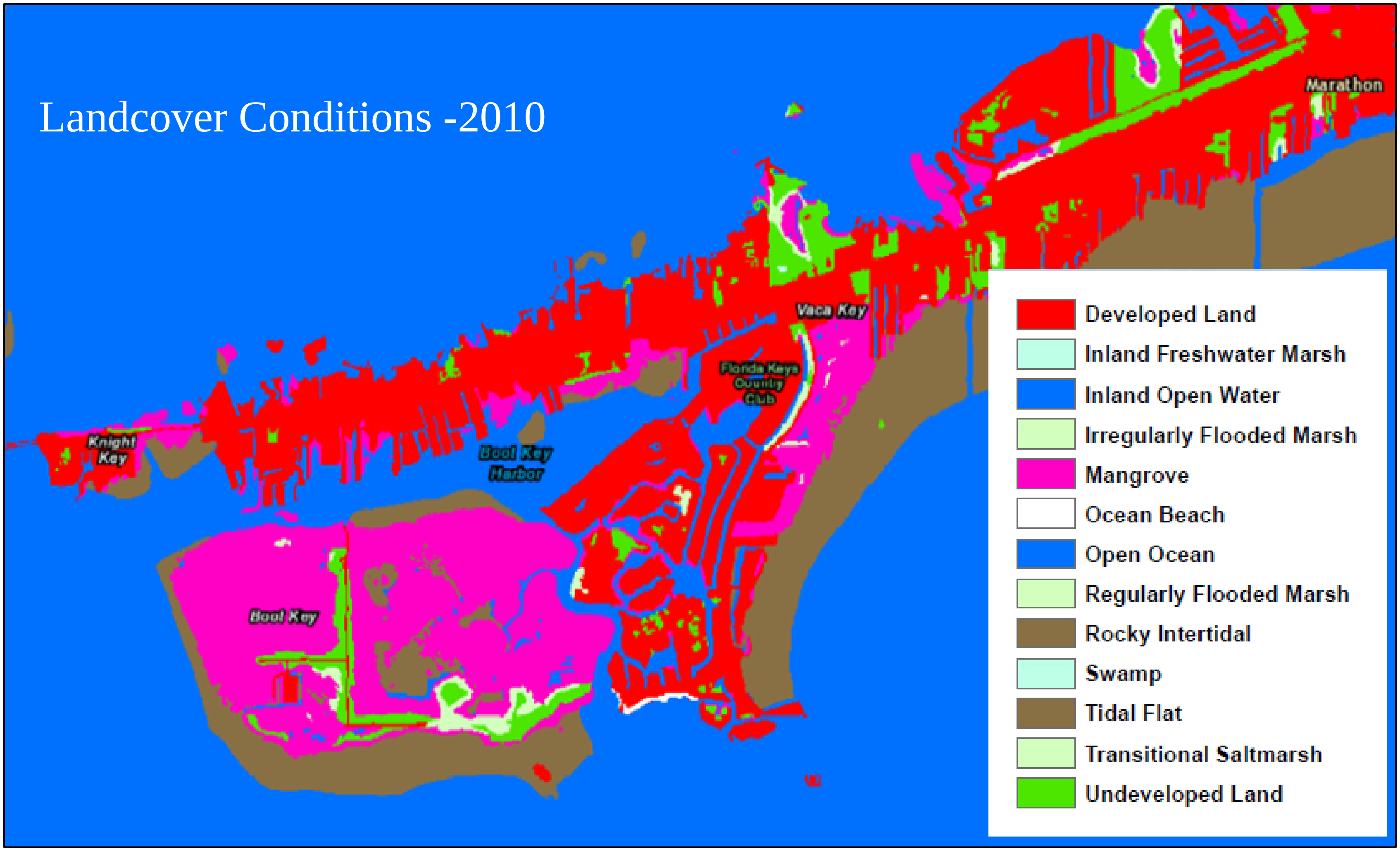

Landcover Conditions -2010
Marathon
Vaca Key
Florida Keys Country Club
Knight Key
Boot Key Harbor
Boot Key
Developed Land
Inland Freshwater Marsh
Inland Open Water
Irregularly Flooded Marsh
Mangrove
Ocean Beach
Open Ocean
Regularly Flooded Marsh
Rocky Intertidal
Swamp
Tidal Flat
Transitional Saltmarsh
Undeveloped Land

Figure 3a

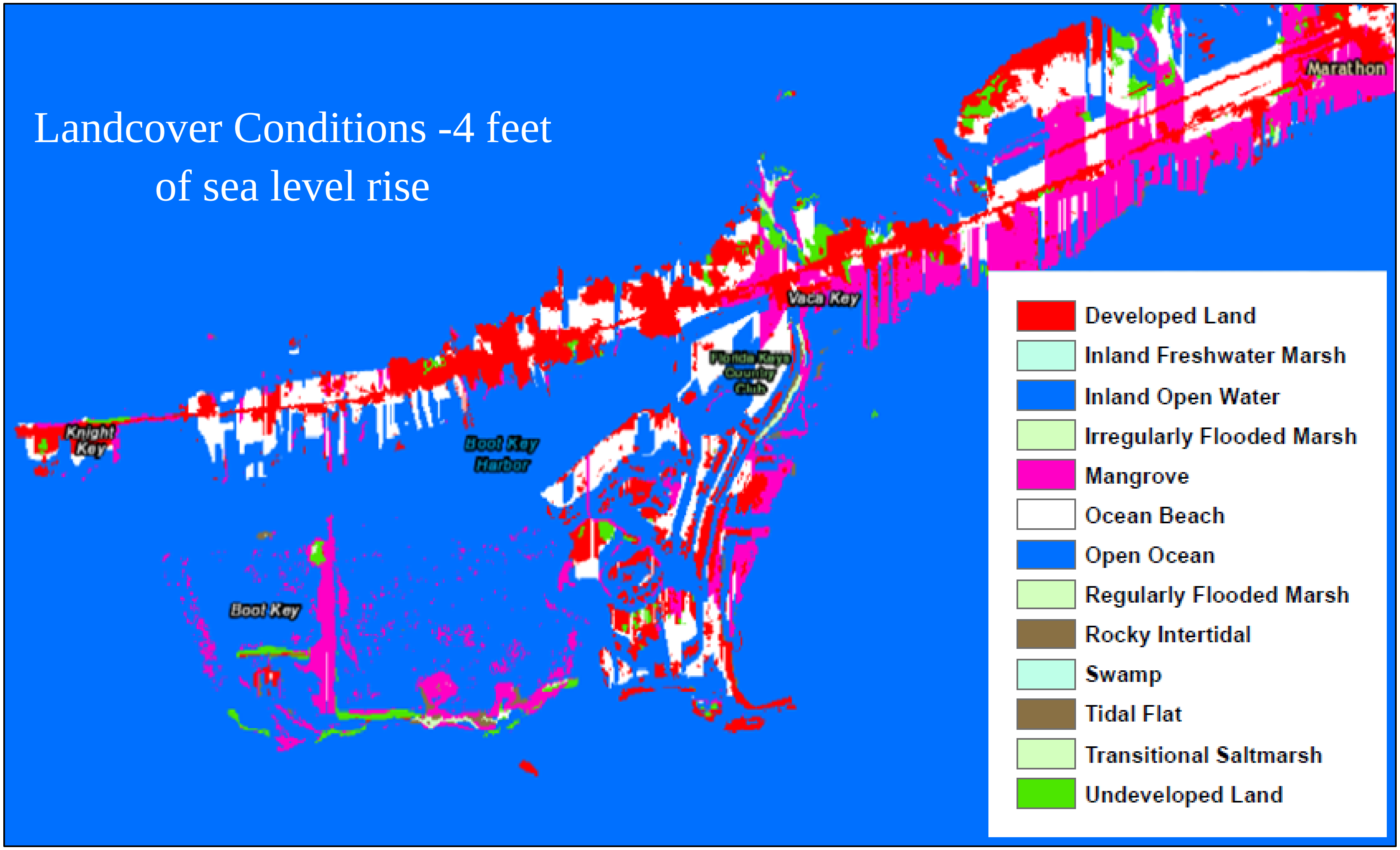


Figure 3b

Figures 3a and 3b. Sea Level Affecting Marsh Model for the western portion of the City of Marathon. This figure represents two of the sea level rise intervals used during workshops. The first map illustrates landcover conditions from 2010 (Fig 3a), which would be considered near current conditions. Figure 3b illustrates the landcover changes resulting from 4 feet of sea level rise.

5.2.3 WORKSHOP 1 – IMPACTS TO SPECIES UNDER SEA LEVEL RISE

The first workshop took place from February 28th to March 1st, 2017 and focused on projecting the impacts to each species and subspecies under each sea level threshold (i.e., 1-ft, 2-ft, 3-ft, 4-ft). We prepared briefing books for each species to ensure each workshop participant was familiar with the species' biology, status, and range; the books also contained project background information and essential terminology. The target audience for Workshop 1 was researchers and biologists who were familiar with the life history of at least one of the 21 species. Participants were broken into two groups for much of the exercises, with one team focused on the vertebrates, and the other focused on plants and invertebrates. After each exercise, participants from each group were given the opportunity to comment on, or add to, the results of the other group. Participants with knowledge on multiple taxa were free to move among groups when needed. Each team was also asked to assign a scribe to record their discussions on worksheets. The agendas for all workshops may be found in Appendix 3.

The workshop was comprised of several exercises designed to determine the vulnerabilities of the selected species and subspecies to sea level rise under future conditions. For the first exercise, participants were asked to provide examples of changes they have already seen occurring in the Keys related to sea level rise, as well as other anthropogenic and naturally-occurring influences impacting the focal species. This exercise was designed to familiarize participants with changes that are already occurring and to assist them in understanding future vulnerabilities. In the second exercise, the workshop participants compared the species distribution maps with the SLAMM habitat succession maps to evaluate potential future impacts to each species under each SLR scenario. This was done to identify which species populations are most susceptible to sea level rise and, conversely, which populations are most secure. This exercise also provided a foundation for the development of adaptation actions for each individual species, suites of species, and habitats where applicable.

Following this discussion, and to provide context to the development of adaptation actions, Bruce Stein, Associate Vice President of the National Wildlife Federation (NWF), gave a presentation on climate adaptation and the Climate Smart Conservation Cycle. This cycle provides a format for examining climate adaptation. While our planning efforts did not follow the Climate Smart Conservation Cycle exactly, it follows the cycle outlined by KeysMAP and has the same guiding principles of climate adaptation.

Using the background from the Climate Smart presentation, each group was asked to review the impacts to the species determined by their team in the previous exercise and to create possible species-specific adaptation approaches. Participants were asked to consider a wide range of possible actions ranging from those that buy time for the species, to more radical approaches such as managed relocations. These actions were distilled into strategies with associated monitoring plans. The monitoring plans were developed to help inform when specific adaptation strategies should be initiated. Where possible, trigger points were determined for each adaptation strategy based on the identified threats (e.g., managing habitats for resilience may be the initial focus until sea level rise reaches a certain trigger point and then focusing on translocation or other extreme strategies). The workshop outputs included a list of potential impacts, actions, monitoring needs, trigger points, and refined distribution maps for the focal species that are still present in the Keys. At the end of the workshop we asked participants to also provide any feedback that might assist in improving the project process (Appendix 4). These workshop exercises were intended to help participants develop a better understanding of the issues that species will face in the Florida Keys, and to begin the dialog about considering active interventions to ensure population viability.

5.2.4 WORKSHOP 2 – PRIORITIZING ADAPTATION OPTIONS

Our second workshop took place April 5th- and 6th, 2017 and focused on prioritization of adaptation actions, determining risks of adaption, discussing adaptive capacity, and examining governance issues. The target audience for this workshop consisted of natural resource managers, planners, and those that could impact policy decisions.

In preparation for this second workshop, a worksheet was developed and distributed to participants prior to the workshop (Appendix 5). The worksheet asked participants to list the focal species that they are currently managing on their lands, and their current objectives for each species. They were then asked to consider the 1 to 4-foot intervals of sea level rise, and to outline any needed changes to their objectives. The purpose of this worksheet was to get participants thinking about their own management goals or policies, and how these may or may not need to change under future conditions.

As in Workshop 1, participants were broken into two groups. Participants were split into groups randomly, and each group was tasked with reviewing all 21 project focal species. After each exercise participants from each group were given the opportunity to comment on or add to the results of the other groups. Each group was also asked to assign a scribe to record their decisions and results on worksheets that were collected by the project team. Before getting started Beth Stys gave a presentation of the Climate Smart Conservation Cycle to provide the new audience with background on climate adaptation and the principals behind adaptation and decision making. The full workshop agenda may be found in Appendix 3.

The first exercise of Workshop 2 was focused on the prioritization of adaptation actions for each of the 21-focal species. Participants were asked to review the recommendations developed in Workshop 1 and come to agreement about which adaptation actions they felt were most important given various sea level rise scenarios. Participants were also given the opportunity to contribute new adaptation actions to the list if they felt a feasible action had been overlooked. At the end of the exercise, groups presented their priority actions back to all participants.

The second exercise of Workshop 2 was focused on assessing risks. Risk is the potential chance of losing something of value, when the chance of that outcome is not well known (NEMC 2010). Risk can occur through either action or inaction. Risk is typically evaluated by examining the likelihood that a consequence will occur, in combination with the expected severity of the consequence. Participants were asked to outline all potential risks and benefits specific adaptation actions might incur. The aim of this exercise was to provide decision makers with as much information as possible when exploring climate adaptation actions for potential implementation.

The two remaining exercises were full group discussions focused on less defined obstacles to climate adaptation; adaptive capacity, and agency policies and planning approaches. Adaptive capacity is the potential or capability of a system to adapt to climatic stimuli or their effects or impacts (IPCC 2001). While this term is often used to examine the ability of an ecosystem to adapt, we chose to focus on the adaptive capacity of the management processes in place related to species conservation and the ability to adapt management based upon the expected impacts to the focal species. Participants were encouraged to identify obstacles to adaptation based upon current agency policy and planning approaches, political viewpoints, or financial constraints. Participants could also suggest ways to build climate change into current policy and planning structure to be more responsive to climate change. The aim of this exercise was to identify obstacles that would need to be overcome to move forward with the priority adaptation actions. Finally, participants were asked to provide feedback (Appendix 4) that might improve the project process (Figure 4).

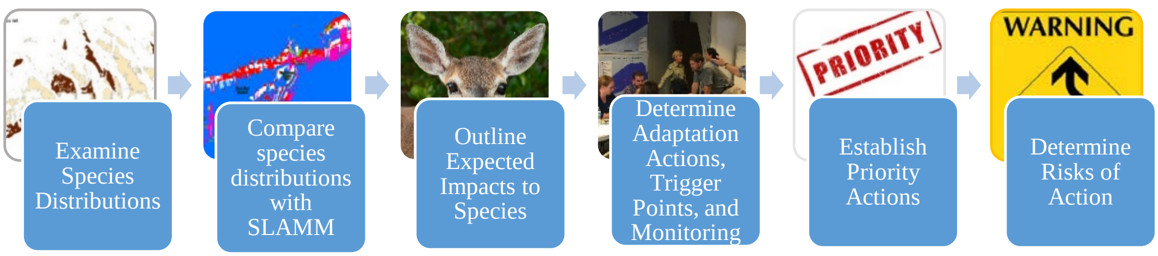


Figure 4. Workshop Process. This figure represents the workshop steps taken during this project.

5.3 RESULTS

During the discussions that focused on changes that have already been observed, Workshop 1 participants identified specific changes to 8 of the focal species; however, it is expected that other focal species have likely experienced similar changes. Participants noted how changes in sea level have impacted the physical environment surrounding these species. Some of the more dramatic changes involved the recent disappearance of a nesting island south of Boca Chica Key (i.e., Pelican Shoal), and the loss of coastal shorebird sampling sites in the Dry Tortugas to open water. Participants also noted that the king tides are getting higher with notable increases on the Boca Chica Naval Air Station and Key West. In developed areas, these king tide inundation events are often manifested through backflooding through storm drains. Participants also noted the slow loss of many other beaches, and the tendency for locals to blame these losses on hurricanes. For the Marquesas and Boca Grande Key, this loss has been tracked via satellite. Images from 1999 to present and have shown gradual coastal loss, and 20-30 meters of upland loss. Shifts were said to be noticeable within 5-year intervals. Specifically, participants noted loss of buttonwood trees in the coastal transition zones, and pine trees dying on low edges of the pine forests.

Our second exercise provided further understanding of the likely impacts to each species under multiple intervals of sea level rise. Species with more fixed populations, such as plants, resulted in more specified impacts. The more cryptic species and those with data gaps were not as clear, though they will likely experience the impacts of sea level rise all the same. Within the final exercise of Workshop 1, participants developed adaptation actions, trigger points, and suggested monitoring efforts for each species.

Some overarching adaptation concepts were identified by the participants at Workshop 2. Actions were considered overarching if they were to be considered for multiple species. These can also be viewed as coarse-filter approaches (Hunter et al. 1988). First, participants determined the need to investigate which species would benefit from infrastructure adaptation actions. For example, if local roads were being raised, species actions that align with raising roads would need to be evaluated. This would require that conservation practitioners were prepared for these opportunities. As an example, some of the more disturbance tolerant species of plants might be planted along newly raised roadsides. Participants also identified the need for joint planning on all long-range actions, including agencies that did not participate in the workshop (DOT, DOD, ACOE).

Examples of species-specific results generated during Workshop 1 are presented below. Further information on each species can be found in Appendix 6.

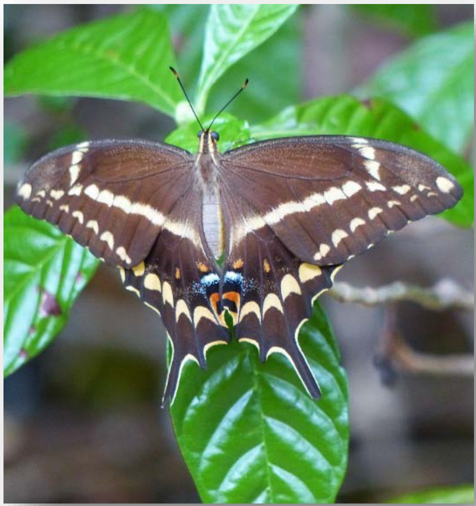
5.3.1 BIG PINE PARTRIDGE PEA (CHAMAECRISTA LINEATA VAR. KEYENSIS)

The Big Pine partridge pea is a small perennial, herbaceous shrub with yellow flowers. This species is considered a distinct species, endemic to the middle Keys. It is known to occur on Cudjoe, Lower Sugarloaf, and on its namesake Big Pine Key. There is also an ex-situ population of plants and a seed bank at Fairchild Botanical Gardens, and many seeds are stored at the National Laboratory for Genetic Resource Preservation. This species occurs in pine rocklands, but also disturbed sites, such as roadsides. Fire plays an important role in the ecology and survival of this species, but controlled burns are difficult to execute in the Keys and wildfire is actively suppressed due to its risks to people and property. Recently this partridge pea has undergone shifts in pollinator assemblage, and timing of flowering and seeding. At the beginning of this project, populations on Cudjoe and Lower Sugarloaf Key were considered lost, and participants suggested no further action be taken at these locations. Based on SLAMM, those populations that still exist on Big Pine Key are expected to see 10% loss at 1 foot of seal level rise, 50% at 2ft, 75% at 3ft, and 90% loss at 4 ft. Participants suggested improving existing habitat on Big Pine Key through prescribed fire to bolster current numbers. Participants also recommended introduction of partridge pea on the higher elevation No Name and Little Pine Keys, through mechanical habitat manipulation and prescribed fire. While introduction to the mainland was discussed, participants felt that research was needed to understand how the partridge pea might interact with related species. A trigger point was set at 2 feet of sea level rise for mainland introductions into the wild (ex-situ), pending positive findings from introduction research.

5.3.2 FLORIDA KEYS TREE CACTUS (*PILOSOCEREUS ROBINII*)

The Key tree-cactus is a large cactus with columnar stems, that can reach up to 10 meters in height. It produces white flowers, and then purplish-red fruits. The tree cactus is endemic to the upper Florida Keys, where it occurs within tropical hardwood hammocks, and transitional woodland habitats, often referred to as cactus hammocks. This species can be confused with the related *P. polygonus*, leading to a potential overestimation of remaining populations. Active efforts are in place to reintroduce the tree cactus to areas it once occurred within the upper keys. However, during our first workshop exercise, participants noted recent outplanting efforts for the tree cactus have been lost to salt water intrusion. There are presently only 6 known populations in the wild. This species will see impacts to 2 of the 6 populations at 1 foot of sea level rise. With each interval of sea level rise more populations will see impacts, and full extinction is likely by 4ft of sea level rise, or sooner, without intervention. Participants suggested continuing efforts for reintroduction, seed and germ plasm collection, and habitat augmentation of this species at higher elevations within their historic range. Establishment of populations on the mainland was suggested at 50% population loss, pending positive outcomes from translocation research. Some participants also wanted to explore the concept of planting this federally endangered cactus on private lands on high ground within the Keys.

5.3.3 SCHAUS SWALLOWTAIL BUTTERFLY (*HERICLIDES ARISTODEMUS PONCEANUS*)



The Schaus swallowtail butterfly is one of Florida’s rarest butterflies, numbering around 800 to 1200 individuals left in the Florida Keys. It is a large dark brown butterfly with yellow, blue, and rust colored markings. This butterfly is endemic to the Florida Keys, where it’s caterpillars feed on torchwood (*Amyris elemifera*) and occasionally wild lime (*Zanthoxylum fagara*). The Schaus swallowtail has recently undergone shifts in timing and frequency of reproduction. This butterfly normally reproduces 1 time per year, but has recently reproduced twice within one year. This butterfly occurs within upland tropical hammocks, and is likely to have persistent habitat up to 4ft of sea level rise on Key Largo. However, the largest population of butterflies currently exists on the lower lying Elliot Key. Participants suggested that habitat management, such as opening canopy gaps, in the upper keys may be the best solution for this species, alongside current efforts to increase host plant numbers. Translocations and host plant enhancement within new public lands and private property was suggested, but it was also noted that current policies may prevent or impede introductions to new areas. Continuing efforts of assurance populations and captive rearing at the McGuire Center for Lepidoptera and Biodiversity was identified as a priority action. If extinction in the Keys becomes likely, participants suggested introduction efforts shift to the mainland.

5.3.4 AMERICAN CROCODILE (*CROCODYLUS ACUTUS*)

The American crocodile is a large gray crocodilian with some mottling. When compared with the American Alligator (*Alligator mississippiensis*), the crocodile has a longer, narrower, and more tapered snout. It occurs in coastal estuarine marshes, tidal swamps, and creek edges. Crocodiles nest on beaches, tidal channel banks, and sometimes levees. The American crocodile has been losing nesting sites within the last 4 years to erosion and inundation caused by sea level rise. Due to the reduction in available nesting sites individual crocodiles have been digging up other nests to make their own. Loss of coastal habitat has also caused crocodiles to move closer to human dwellings, with some nesting occurring in residential areas. Participants felt that trigger points related to sea level rise may have already been reached for this species. They identified the need to build artificial nesting sites, and to continue to add substrate to existing artificial nesting areas. The creation of floating nesting sites was listed as a potential action, but with consideration of appropriate nearby nursery habitat for hatchlings. Participants also felt that further research was needed to validate that crocodiles may naturally be expanding their range northward, while also monitoring for nesting success.

5.3.5 KEY DEER (ODOCOILEUS VIRGINIANUS CLAVIUM)

The Key deer is a small subspecies of the white-tailed deer. They live on approximately 20 islands in the middle Keys. They are generalists in their habitat use, being found in mangroves, hammocks, pine forests, wetlands, and urban areas. The major concern noted by participants was availability of freshwater. At 1 foot of sea level rise participants identified a 37% loss in freshwater resources, and complete loss of freshwater by 2 feet. It was also noted that a major salinization event, such as a hurricane, could temporarily eliminate the freshwater sooner. Therefore, most of the identified adaptation actions call for creating temporary or permanent freshwater resources for the deer. Participants also felt that captive assurance populations needed to be established now. Managers may also need to consider moving key deer to additional locations within the Keys, even if they are not within known historic ranges. Participants discussed the concept of establishing breeding populations of Key deer on the mainland in reserves or zoos. While many were concerned with potential crossing with mainland deer, many felt that this may be the best option in preventing eventual extinction.

5.3.6 KEY LARGO WOODRAT (NEOTOMA FLORIDANA SMALLI)

The Key Largo woodrat is a large rat associated with the tropical hardwood hammocks in northern protected lands in its namesake Key Largo. It requires vegetative matter from hardwood hammocks as the basis of its nesting material. Predation by domestic cats currently poses one of the largest threats to the Key Largo woodrat. However, Burmese python predation has been documented and more pythons have recently been confirmed in the northern Keys could further increase predation pressures. The Key Largo woodrat's distribution is also experiencing constriction due to expanding mangrove and contracting upland areas combined with fixed human infrastructure. As mangroves move upslope into ideal upland woodrat habitat the animals are forced closer to roads where vehicle strikes are a cause of mortality. The increase in mangrove presence has also led to an adjustment in woodrat behavior. Some have started using mangrove propagules for nesting material instead of the typical hardwood sticks. The potential habitat for the woodrat should be available with up to 4 feet of sea level rise, but being pushed inland may further expose them to predation pressures and vehicle strikes. Participants felt that most adaptation should focus on reducing predation pressures and increasing pathways for radiation. Decreasing predation pressure would primarily focus on pathways to reducing feral and outdoor cat populations and maintaining early detection and rapid response efforts for pythons. Allowing for radiation may entail increasing canopy over roads to allow for arboreal transit or ensuring dry bridges through mangrove stands between upland habitat patches. Participants also noted the need to continue and increase current efforts to create artificial nesting sites.

5.3.7 THE LOWER KEYS MARSH RABBIT (*SYLVILAGUS PALUSTRIS HEFNERI*)

This small short eared rabbit, found primarily in grassy marsh and prairie habitats. This species is reliant on freshwater availability and the transition zone between coastal wetlands and uplands. Marsh rabbits are sometimes found in the mangrove transitional zone, but they require a nearby source of freshwater. The Lower Keys marsh rabbit's habitat is being lost on the naval base, and rabbit population numbers in coastal areas are wildly variable and often crash in the aftermath of disturbance events. However, these coastal sites quickly fill back in with new rabbit recruits. This may be due to the freshwater areas nearby serving as a refugia and repopulation source for the coastal populations. Much like the Key deer, the long-term success of the marsh rabbit will require continuing freshwater availability. Participants thought that there was potential for freshwater availability on Big Pine Key and other pine islands with up to 3 feet of sea level rise, but the water would most likely be brackish by that point. Primarily participants felt that creating higher elevation marshes, and restoring additional marshes would lead to longer term success. An opportunity was identified to partner with the naval base in Key West to create higher elevation wetlands. Previous airfield conversion work on the naval base altered the hydrology of the site, resulting in local population increases for the marsh rabbit. As the Navy works to raise infrastructure, artificial wetlands could be created as well to further ensure a longer-term habitat for the marsh rabbit.

5.3.8 SPECIFIC RISKS ASSOCIATED WITH ADAPTATION ACTIONS

During Workshop 3 participants reviewed a subset of the priority adaptation actions to determine what risks or benefits may be associated with those actions. Each determined benefit or risk is listed below each reviewed action (Tables 22-26). The participants determined that risks vary based on the duration or permanence of an action, but, in general, exposure to risk is less with in situ and temporary actions. As an example, the action of providing supplemental freshwater for key deer was thought to have less risk associated if the action is short term, post-hurricane. If watering stations were made permanent, it was thought that the increase in exposure time would also increase the risks associated with the action (Table 22) A permanent supplemental freshwater source would also likely be higher in cost than temporary supplemental water stations.

Participants discussed the potential for some of these actions to become too risky if the species starts doing well in other areas, while its Keys populations become hopeless. This was referred to as a reverse trigger point by participants. The reverse trigger point takes place when action within the Keys is no longer viable, and efforts must shift elsewhere (i.e. mainland populations, or a different species entirely). An example of this situation could occur for species like the crocodile. If their populations on the mainland started to increase, then we could potentially decrease Keys efforts for that species. This could potentially shift resources to other Keys species, or shift resources to other areas outside the Keys. However, most species endemic to the Keys have little ability to establish on the mainland without ex-situ conservation actions. These endemic species face the highest amount of risk to their overall population when it comes to actions or inaction.

Table 2. Key deer discussion. This table represents the discussion of one adaptation action focused on the persistence of key deer. Information is organized by any identified benefits, risks, benefits of inaction, or risks of inaction.

Provide artificial watering for key deer (including temporary emergency water supplementation and later, permanent water sources)	
Benefits:	• Other species could benefit from freshwater source • Increased or maintained key deer survival and herd size
Risks:	• Altered behavior • Disease spreads among animals • Artificially altering carrying capacity leading to negative impacts on other plant/animal species • Temporary storm surge events may be a natural limiting factor for key deer populations • Cost and logistics • Modification of landscape required to implement action • Harboring mosquitos/spreading disease to humans • Increased human-deer interactions and habitat clashes including vehicle collisions • Risk of negative public perceptions • Exotic or undesirable species could benefit • Increased competition or predation
Benefits of Inaction	• Current population could be as high as double the natural carrying capacity (Lopez 2001, Barret and Stiling 2006) due to supplemental resources, so inaction may lead to benefits for other species and more sustainable carrying capacity for available habitat
Risks of Inaction	• Deer morbidity and mortality: we may see deer suffering and dying from dehydration • Population decline and possible extinction

Table 3. Hammock habitat discussion. This table represents the discussion of one adaptation action focused on the persistence of canopy disturbance species (i.e. Schaus swallowtail, Keys tree cactus). Information is organized by any identified benefits, risks, benefits of inaction, or risks of inaction.

Create disturbance via mechanical clearing in hammock habitat to create canopy openings	
Benefits	• Potential to benefit other species that like disturbance
Risks	• Exotic invasion • Artificial disturbance doesn't truly mimic natural events • Change in microclimatic would impact ecological community • Action is labor intensive, costly, and not guaranteed to work
Benefits of Inaction	• Climate change, weather events and wildfire may create disturbance so direct action may not be necessary
Risks of Inaction	• Reduced availability of disturbed sites for species that require canopy openings.

Table 4. Semaphore cactus and Keys tree cactus discussion. This table represents the discussion of one adaptation action focused on the persistence of the semaphore and Keys tree cactus. Information is organized by any identified benefits, risks, benefits of inaction, or risks of inaction.

Action: Provide semaphore cactus (or other T&E species) to private landowners to grow on higher ground	
Benefits	• Semaphore cactus might have a higher probability survival if it becomes more widely available • Filling data gaps • Possibly increasing resilience by spreading risk amongst more populations
Risks	• Encouraging people to intervene can be a slippery slope leading to collection in the wild • Species could get out of control • Spread of disease
Benefits of Inaction	• None determined
Risks of Inaction	• The number of outplanting sites for individual species remains limited to designated conservation lands, many of which are low-lying

Table 5. Crocodile Nest Discussion. This table represents the discussion of one adaptation action focused on the persistence of the nesting American crocodiles in the Florida Keys. Information is organized by any identified benefits, risks, benefits of inaction, or risks of inaction.

Action: Create artificial nesting sites for crocodiles	
Benefits	• Higher hatchling survival • Possibly more stable sex ratios • Habitat could be used by other species, such as birds • Crocodiles could be good predators for pythons
Risks	• Habitat can be invaded by other species (fire ants, plants, rodents, etc.) • Promoting nesting in an area that is not going to be optimal for other life cycle stages long term • If they can be more successful north, do we want to risk the resources here? • Increasing interactions with humans
Benefits of Inaction	• None identified
Risks of Inaction	• Reduced available nesting sites for American crocodiles in the Florida Keys

Table 6. Crocodile Incubation Discussion. This table represents the discussion of one adaptation action focused on the persistence of the successful hatching of American crocodiles in the Florida Keys. Information is organized by any identified benefits, risks, benefits of inaction, or risks of inaction.

Action: Altering nesting temperatures to ensure desired sex ratios	
Benefits	• Could get desired sex ratio • Continual hatching and therefore preservation of Keys population genetics
Risks	• May not be successful, did not work well with sea turtles • Artificial shading would attract unwanted attention to nesting sites • Change the temperature too much in the other direction
Benefits of Inaction	• None identified
Risks of Inaction	• Reduction of successful hatching of American crocodiles in the Florida Keys. Potential for changing sex ratios.

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5.3.9 EX-SITU ADAPTATION OPTIONS

Throughout each workshop, participants discussed many ex-situ options for individual species. While these options vary from species to species, they boil down to a few overarching concepts. These concepts are represented in Table 7 below.

Table 7. Ex-situ adaptation options This table contains a range of ex-situ-based adaptation options.

Ex-Situ Options	
	• Gene banking and seed banking • Establish a captive breeding and assurance populations where possible (e.g. AZA accredited facilities) • Managed relocation within the Keys, but outside of historic range • Assisted migration from Lower Keys to the Upper Keys and eventually South Florida (matching SLR) • Assisted migration from the Keys directly to mainland Florida • Assisted migration from the Keys to another country (e.g. Bahamas) • Assisted evolution; hybridization with mainland species to conserve the genetics and potentially increase survivability under future conditions

The primary topic of discussion during surrounding these ex-situ options was the ethical question of moving species outside of their naturally occurring or historical ranges into new natural habitat. While some participants felt that moving species was an ideal approach, others felt strongly that such moves should never occur. Overall most believed it could be done with limited implementation after careful examination of risks. We captured this discussion and outlined the technical challenges and ethical questions participants identified below in Table 8.

5.3.10 SPECIES TRANSLOCATIONS

Table 8. Species Translocation Discussion. This table contains some of the arguments for and against the translocation of species outside of their historic ranges.

Species Translocation	
Technical Challenges	• Identification of receiver sites could be a challenge politically and biologically and testing is necessary • Relocation onto private lands is a hurdle • Some species may be more difficult and complicated to translocate (a large mammal is more difficult than a plant). Perhaps it’s a good idea to start with plants and get some of logistics worked out before moving up the chain to animals • We probably need a more purposeful decision tree for this. For example, when do we begin captive breeding? Some decision trees already exist and should be evaluated for their efficacy.

	• Understanding the risks and consequences is important and there is currently not a central policy – agencies need to look more carefully at decision making process and improving consistency and transparency • Risk of creating a biological invasion • Risk of contaminating genetics of related subspecies at the receiver site • Risk of negative public perception about manipulating nature
Ethical issues	• What things can we do, technically speaking? What things are we willing to do? What would it take for us to pull the trigger on more drastic actions such as translocation? • Allowing species to expand naturally: is this ethical if they begin doing damage? How is this ethically different from "helping" them via translocation if humans have altered the environment and species associations anyway (Anthropocene)? • Should species that don't have the ability to move naturally be treated differently from those that do? • If a species moves naturally and is threatening an endangered species, do we intervene then? • What if species hybridize naturally and that hybrid is the species that can adapt most successfully? Do we prevent hybrid that are occurring naturally, and may be best suited for future? If so, do we actively seek the climate adaptive hybridization (assisted evolution)? • At what point, do you give up on a species if it can't move on its own? What would make it worth keeping a species? What is the decision point where society would be willing to let a species go extinct?

5.3.11 AGENCY POLICY AND PLANNING

During Workshop 2 participants discussed challenges in carrying out adaptation based upon their agency structures and policies. This discussion revealed that many participants felt that their current agency structure isn't conducive to proper implementation of climate adaptation strategies. The main issues identified by participants were inflexibility in both planning structures and upper management. Many participants felt that they were unable to move forward with actions due to the political climates giving pause to management, or indifference or mindset of individuals. Another major issue identified by participants was funding for adaptation. One participant noted that the current funding streams that are available for adaptive management are one-time funds tied directly to specific goals and objectives; however, effective adaptive management requires flexibility to adjust strategies should needs arise. This pointed out the weakness in the request for proposals process and the inability to integrate adaptive management into these processes. Often planning can be out of line with grant funding cycles, however the term limitation of funding can also be problematic. Climate adaptation strategies may require revisiting the actions as changes occur, and many grants streams could see this as a repeated effort and not provide funding. This discussion highlighted needed changes to policy, and propose new methodologies. Further notes can be found below in Table 9.

Table 9. Notes from Agency Policy and Planning Discussion. This table represents the main roadblocks to adaptation identified by Workshop 2 participants, as they relate to planning and policies within their agencies.

Roadblocks	• Mindsets can be inflexible and difficult to shift; • Many agencies are stuck in a planning rut, and are not moving into implementation • Out of date plans not being revised • Challenge of doing adaptive management and associated bureaucracy: most are happy to develop and implement a plan initially but there is no way to finance the ability to reassess, monitor, and make changes to a project. • Adaptive management requires fixing projects and making changes, this can be difficult
Needs	• A climate adaptation fund that allows for quick reactions and adjusting projects that don't go as planned. There is currently no way to put this money aside. • Built in flexibility to adjust and deviate from a plan– not just financially but also operationally. Plans are typically locked in after moving through regulatory processes necessary in an agency. • Get the uncertainty and possible scenarios approved initially for plans, and build in contingency actions.

5.3.12 ADAPTIVE CAPACITY

The final discussion of Workshop 2 focused on adaptive capacity. For the purposes of this project, adaptive capacity referred to a practitioner's ability to execute an action based upon current political and public viewpoints. Some actions deemed as necessary by some planners may be viewed as immoral or unethical by others. For example, one of the major threats identified to multiple species within the Keys are domestic cats. Due to their impact on wildlife, there is a need to remove and or control cat populations in the Keys. While some organizations have been able to enact these measures, the controversial nature of these actions limits larger scale implementation.

5.4 DISCUSSION

Sea levels are rising and will continue to rise for the foreseeable future throughout the coastal US. Difficult decisions will need to be made nationwide. Having a well-developed process and supportive decision-making processes are therefore critical to conservation anywhere sea level rise threatens wildlife. Our goal in this project was to evaluate effective adaptation options for Florida Keys species with an eye towards relevance to other regions where managers are dealing with similarly daunting issues. To accomplish this, we sought to create a clear and simple methodology to approaching climate adaptation planning that resource managers could easily apply to multiple similar conservation targets.

Our process was based on the FWC modified Climate Smart approach (Figure 1.) This approach integrates science and management to 1) identify the salient issue(s); 2) use the best available science, modeling, and expert elucidation to project the impacts from the future effects of climate change on specific species/suites of species; 3) address the potential impacts to the species by developing adaptation options; 4) prioritize the options that are available; 5) identify triggerpoints that guide when to implement the strategy; 6) develop monitoring programs that let mangers know when the triggerpoint has been reached; 7) implement.

Trigger points became a focus of the workshops because they dictate when adaptation strategies should be initiated. Some species' trigger points were easier for participants to identify than others. It was easier for participants to identify trigger points for those species with fewer data gaps and those with fixed distributions (i.e., plants). Identifying these trigger points helps us understand the urgency of adaptation actions. It is also important to remember that these triggers are not a certainty but provide managers and planners with more tangible targets for action. These trigger points will occur with or without us anticipating them but being prepared for their inevitability will allow for higher success in preventing the complete loss of these species.

The implementation step in the process is particularly vexing given the many barriers to execution. Many of these barriers reflect on the intransigence of the governance structures including the inflexibility in rules that govern T&E species management, and the inability of managers to either make the tough decisions to implement climate adaptation strategies, or to provide the support for their subordinates to make the tough decisions. In that context, we recognized the importance of identifying barriers and developing strategies to overcome these barriers and suggest that implementation planning which incorporates overcoming barriers needs to be part of any implementation process. In this way, implementation can be approached strategically.

During Workshop 1, participants determined predictably that some species will face the impacts of sea level rise sooner than others. Managers were aware that some species have already reached the trigger point thus implying that immediate adaptation action is needed (e.g., Key tree cactus). Future spatial habitat projections (i.e., SLAMM) and current species range maps were instrumental in that determination; however, some managers already recognize the vulnerability of these species and corrective action have been proposed. In the case of the Key tree cactus, The Village of Islamorada now manages the Key Tree Cactus Nature Preserve to address the species' vulnerability.

We relied on SLAMM to provide context for discussion of possible impacts to habitats and how those impacts could alter species' persistence. However, the SLAMM outputs alone were not sufficient for the development of targeted adaptation actions given the uncertainty associated with models in general and SLAMM in particular. As mentioned. SLAMM simply served to provide context for discussions and thus overcoming potential planning paralysis. However, comparing SLAMM habitat projects to species distribution maps provided a very simple approach that allowed participants to clearly visualize where each species may see impacts at a given stage of sea level, and some recognition as to how severe those impacts may be. Taken together, these provided a context for developing appropriate adaptation options.

Examining multiple intervals of sea level rise (i.e., 1, 2, 3, and 4ft), provided the further insight into identifying which population are most at risk, and, conversely, which may be secure for longer. Species that were more generalists (e.g., Key Deer) likely will persist longer given their ability to disperse on the limited landscape and their ability to occupy diverse habitats. Others including those linked inextricably to specific threatened habitats or host species (e.g., Bartram's hairstreak, Key tree cactus, Big Pine partridge pea) are more vulnerable and their ability to persist under changing conditions is questionable.

We found that decoupling the element of time from the intervals of sea level rise allowed us to approach each discussion without participants considering whether higher SLR intervals would be seen within their career. In past scenario planning efforts, we have found that participants are apprehensive about planning for projects as far away as 2100. Removing this conceptual obstruction allowed for the development and consideration of more forward-looking adaptation options, rather than short-term solutions that may not provide long-term success.

Participants found that data gaps in species distribution and life history were the most difficult obstacles on all levels. For example, some species' vulnerabilities and associated trigger points were elusive due to uncertainties about the basic biology and distribution of the species (e.g., the silver rice rat). Resolving these data gaps then become an identified priority for these species before adaptation options could be crafted for them.

However, in many cases where data were poor, there was a general recognition that using SLAMM model projections, the available data on biology and range of the species, and the input of expert was sufficient to craft adaptation strategies (e.g., the Stock Island tree snail). This is critically important because there is all too often mangers give the excuse for inaction that there are not enough data and that more is needed.

While our project focus was on impacts of sea level rise on Keys threatened and endangered species, participants determined that sea level rise may not be the most existential threat. All of the small mammals in our study are faced with impacts from feral cats. As a result, many of the in-situ adaptation discussions and actions for these species focused on feral cat control. There was a strong consensus that feral cats must be addressed or else these species will face imminent extinction. If they do persist, sea level rise will further compound the threats to these species because the preferred habitats of many of them will contract thus resulting in increased interactions with feral cats. This issue should form the basis for immediate action.

Other non-climate stressors also represent existential threats for a number of species. Habitat loss and host plant availability was the limiting factor identified for all the butterflies, and many felt that these butterflies may disappear long before the first interval of sea level rise (1ft). The Stock Island tree snail is threatened by an invasive, predatory flat worm that could reduce its populations long before northern Key Largo populations would be impacted by rising seas. While sea level rise was the focus of our discussions, these additional impacts require solutions.

When planning for adaptation actions during workshops, we worked within an environment free from direct personal consequences or political considerations. This allowed participants to discuss options outside of current social, political, or technological constraints. Even within this environment, participants found it hard to think outside of their comfort zones. Participants were more comfortable proposing approaches that are extensions of current management actions. This comfort may provide participants the feeling that they have determined optimal solutions for each species without recognizing the constraints under which they subconsciously operate. To make sure all adaptation options were considered, we pushed participants beyond this boundary by encouraging ‘outside the box’ thinking. However, the prioritization process by necessity must be coupled with an understanding of the risks associated with their actions.

While each action is designed with the best intentions, we can’t ignore that some actions could instead be maladaptive and have negative repercussions rather than help the species. Any planning effort must also incorporate discussions surrounding risks. The risks associated with these actions must then be weighed against the risks of inaction. In the case of the Florida Keys endemics, inaction will eventually result in complete loss of all species given the inevitability of SLR ultimately inundating the islands.

While important groundwork has been laid, adaptation efforts do not end here for the project species. Adaptation, as it pertains to species management, is a continuum requiring periodic revisiting and revising. To truly be adaptive requires a flexible approach to management. To meet this requirement, a long term multi-organizational team focused on the implementation and evaluation of adaptation actions is necessary. Such a team must expand beyond those who participated in our project, as staff turnover may limit long term success. Furthermore, it is near impossible to assemble all the experts either relating to science and management at any one time. Follow-up activities are necessary to ensure that the latest information is available.

All coastal regions face the threat of sea level rise and the low-lying Florida Keys will be among the first locations faced with the loss of endemic species from this threat. It is this fact that makes future planning so important, and the Keys are quite literally at ground zero. The species outlined in this project are mostly limited to the Keys, but the methodology we described was designed to be relevant to planning for imperiled species in general.

The Florida Keys may face these issues sooner than others, but climate adaptation planning is of great national importance. It is our hope that the process and lessons learned within this project may be applied throughout the U.S., and beyond.

5.5 CONCLUSIONS

Some of the important take-away messages from this project are as follows. Many of these are directly applicable to projects with similar goals that are beyond the Florida Keys region.

- **In many cases there is sufficient existing knowledge to make robust decisions.** We found that many of the species that we examined had sufficient information available to develop informed and robust adaptation options. The experts that we engaged only identified a small number of species for which there was insufficient knowledge to fully identify the consequences of climate change or other impacts from non-climate stressors.
- **Non-climate stressors can be equally or more important than climate-based stressors**. This is especially true in the short term when impacts from non-climate stressors may be much more consequential (e.g., pollution, predation from invasive species including predators, and loss of habitat from coastal development).
- **Models have limitations**. You need experienced managers to interpret the models and to use them to contextualize adaptation options.
- **There is value in removing time-to-an-event from the discussion.** Removing the element of time from sea level rise adaptation planning may reduce the baggage associated with specific time periods. Additionally, time steps that are further from the present may be more abstract to planners and, therefore, harder to plan for
- **Priorities must be established based on social and economic values.** In some cases, resources must be prioritized for species at greater risk or more socially or economically valuable species. **Risks must be assessed to reduce vulnerabilities.** Risks have multiple dimensions including the risks associated with action and inaction. Each of these should be assessed on a species by species basis or based on species with shared vulnerabilities. Adaptation planning requires understanding the species-specific risk profiles and tailoring responses based on those profiles.
- **Adaptation as it pertains to species management is by design an ongoing process requiring periodic revisiting and revising**. The Climate-Smart model emphasizes continually revisiting goals, objectives, approaches, and strategies.
- **To truly be adaptive requires a flexible approach to management at all levels**. For example, workshop participants recognized that funding sources often by design focused on very specific deliverables which, in an adaptive environment, is often not realistic. Funding should be accommodating to changing conditions.
- **Representatives of multiple disciplines that focus on social, economic, and ethical values must be at the table** to ensure that adaptation options have support from sectors that can influence and/or ensure successful implementation of strategies. Climate change adaptation has potential impacts on many sectors and adaptation for natural resources may be a lower social priority (e.g., when compared with human health). Therefore, if

representatives from the natural resource sector can combine with representatives from other sectors to develop multi-dimensional adaptation strategies, there will be a greater opportunity to ensure that the priorities of natural resource managers are achieved.

- **Implementation is difficult, and ways must be found to move forward with implementing strategies.** Although implementation was not a focus of this project, the project team understood that perhaps the most difficult part of adaptation, especially in the Climate-Smart model, is the implementation phase. However, this was a point of discussion in Workshop 2 and the participants agreed to form an ad hoc working group focused on implementation.

6. PROJECT PHASE II: MANAGING FOR CHANGE

6.1 OBJECTIVES

Objective 1: Examine managing for change and not just for persistence

Objective 2: Determine and categorize barriers to implementation of adaptation actions, utilizing three case studies

Objective 3: Develop methods to overcome or eliminate barriers for each case study

Objective 4: Examine how this work fits the bigger picture for climate adaptation implementation

6.2 METHODS

While the threat of climate change has become widely recognized by natural resource managers, implementing management actions to mitigate those threats is still rare. Natural resource managers commonly look to peers for lessons learned to resolve their issues. Despite the fact that many methodologies have been developed with planning for climate adaptation actions in mind (National Park Service 2013, Rowland et al. 2014, Stein et al. 2014, Vargas-Moreno 2013), guidelines for implementing those actions are still underdeveloped.

To develop further steps for implementing climate adaptation, the Florida Fish and Wildlife Conservation Commission, the US Fish and Wildlife Service, and The Nature Conservancy teamed up to host a climate adaptation workshop focused on the lack of implementation of climate adaptation actions in natural resource management. To properly tackle such an expansive and daunting issue, we determined it was necessary to enlarge our project team. We sought additional experts in climate adaptation from outside the South East and added an additional team member from FWC. Bruce Stein of The National Wildlife Federation, Molly Cross of the Wildlife Conservation Society, Gregor Schuurman of the National Parks Service, and Lily Swanbrow-Becker of FWC were recruited to help steer and execute the next phase of the project.

After our initial planning calls, it became clearer that implementing climate adaptation actions was not an issue unique to the Florida Keys, or Florida as a whole. To guide our planning efforts, we focused on the following goal: <u>To determine barriers to implementing climate adaptation actions, and how to overcome them.</u> While barriers and limitations are often used interchangeably, for the purposes of this project, their differences are important. Limitations can be considered as insurmountable now, or an obstacle that is absolute. However, a barrier can be considered as an obstacle that can be overcome with effort. Some adaptation actions proposed may have barriers to implementation but may also have a limit beyond those barriers.

STAPLEE Categories:
1. Social
2. Technical
3. Administrative
4. Political
5. Legal and Governance
6. Economic
7. Environmental

We adapted the STAPLEE method (FEMA 2003) to examine categories of barriers and limitations to adaptation implementation. This method facilitated a wider thought process by asking users to evaluate the **S**ocial, **T**echnical, **A**dministrative, **P**olitical, **L**egal, **E**conomic, and **E**nvironmental (STAPLEE) perspectives. The STAPLEE method was originally created by the Federal Emergency Management Agency (FEMA) for the quick evaluation of disaster mitigation actions. This approach was used to prioritize adaptation options in the KeysMAP2 project (Vargas-Moreno et al., 2017). These categories were intended to assist participants to examine barriers that they may not normally consider.

To help us meet this goal, we defined 4 objectives to be accomplished based on the results of Workshop 3. Two of these objectives were aimed directly at accomplishing our newly-defined goal of identifying and overcoming barriers, while the other two were set to help contextualize this information. With our new goal and objectives guiding us, we developed key questions that would help frame discussions and progress the workshop. Questions were categorized based on the objective they were helping to accomplish. Framing the questions in this manner also assisted in the development of workshop exercises.

Workshop 3 Objectives
1. Examine managing for change and not just for persistence
2. Determine and categorize barriers to implementation of adaptation actions, utilizing three case studies
3. Develop methods to overcome or eliminate barriers for each case study
4. Examine how this work fits the bigger picture for climate adaptation implementation

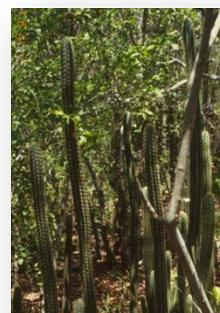
Our main questions were: "In the face of hard choices, what makes people stop short of acting and how can we resist inaction (i.e. what are the barriers)?", and "What does managing for change look like?". More specifically, how might you manage for change in an endangered habitat full of endemic species with no ability to migrate its characteristic habitat features. While some characteristic species may be able to move outside of a habitat, the geological features of that habitat cannot. What habitat will form within these fixed geological features, and should we facilitate or resist that change? While we focused our questions around Florida Keys work, natural resource managers throughout the United States and beyond will need to address them based on local priorities. Our team determined that we must work to make the products of this workshop widely applicable.

Once the proper questions were outlined, we deliberated on who might be the best participants to answer them. To ensure a broad suite of perspectives related to barriers, we invited experts from throughout the country representing a diverse range of backgrounds including psychology, law, climate adaptation, governance, social justice, biology, decision-making, natural resources policy, land-use planning and policy, human dimensions, communication, and economics. All the experts were selected based on their backgrounds of integrating climate change into their respective disciplines.

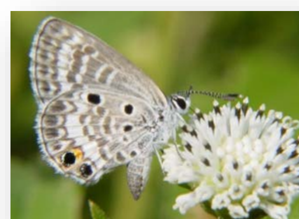
We determined our case study species would be federally listed species from the Florida Keys: the Lower Keys marsh rabbit, the Keys tree cactus, and the Miami blue butterfly. The species selected come from diverse taxonomic groups, habitats, and likely varied societal value and public recognition. Ideally, these characteristics pose unique barriers to adaptation implementation, and equally unique methods to overcome them. This approach also allowed us to examine if t our methods could be applied generally to other species or issues.

1. The Lower Keys Marsh rabbit (*Sylvilagus palustris hefneri*) is a small, short-eared rabbit reliant on freshwater availability and is found in the transition zone between coastal wetlands and uplands in the lower Keys. It is possible that habitat and freshwater availability for this species will persist up to 3 feet of sea level rise, but water resources would most likely be brackish and populations numbers low.

2. The Key tree-cactus (*Pilosocereus robinii*) is a large cactus with columnar stems endemic to the upper Florida Keys where it occurs within tropical hardwood hammocks, and transitional woodland habitats which are often referred to as cactus hammocks. Active efforts are in place to reintroduce the tree cactus to areas it once occurred within the upper keys. However, many outplanting efforts for the tree cactus have failed due to salt water intrusion. There are presently only 6 known populations in the wild. The Village of Islamorada manages the Keys Tree Cactus preserve.



3. The Miami blue (*Cyclargus thomasi bethunebakeri)* is a small brightly colored butterfly, endemic only to South Florida. This species occupies tropical hardwood hammocks, pine rocklands, and beachside scrub, where it utilizes multiple hostplants including balloonvine (*Cardiospermum spp*.), gray nickerbean (*Caesalpinia bonduc*), and blackbead (*Pithecellobium keyensis*.). Due to its limited range and coastal proximity, the species is especially vulnerable to extinction from stochastic events and sea level rise.



Our primary goal was *to determine barriers to implementing climate adaptation actions, and how to overcome them.* Secondarily, we examined *what does it mean to manage for change*. Lastly, we established next steps and specific products emanating from this workshop. The agenda can be found in Appendix 3.3

6.2.1 WORKSHOP EXECUTION

The workshop began with a plenary session where participants presented results of their work on climate change from a wide range of perspectives such as psychology, law, city planning, and communication. These talks were intentionally diverse, with the hope that they would inspire participants to think broadly and without restrictions during workshop exercises. During the workshop, participants were asked to follow a methodology of evaluating barriers to climate adaptation actions and how to overcome them for the 3 case study species.

We utilized a web-based tool called MeetingSphere (MeetingSphere Inc. Norfolk Virginia USA, www.meetingsphere.com) that allowed participants to provide their input electronically in their own words. This provided the chance to capture large volumes of information at a much faster rate and with statistical rigor. Prior to the exercises, we conducted an introduction to the tool and methodology of identifying barriers using a case study. This case study focused on managing for change within the pine rocklands habitat. Participants were first asked to review select adaptation actions suggested by participants from previous planning efforts. Following this review, each participant voted on their top 3 priority adaptation actions. These votes were combined, resulting in a succinct list of high priority actions.

Table 1.1. Pine Rockland Prioritization. This table illustrates the MeetingSphere pine rockland adaptation actions prioritization voting results by workshop participants. Actions are sorted from greatest number of selections, or votes, to the least.

Pine rocklands – Priority Adaptation Strategies sorted by Sum

Rank	Action	Selections
1	Allow/assist transition of pine rocklands to tropical hardwood hammock (or some other community)	10
2	Create pine rockland community in new areas at minimal threat from SLR	10
3	Maintain current management (prescribed fire) as best possible until habitat is lost to sea level rise	10
4	Relocate pine rocklands species to pine flatwoods (or other suitable sites)	9
5	Evaluate alternative management actions to replace prescribed fire to maintain pine rocklands	8
6	Translocate pine rockland species to Caribbean pine rocklands (e.g. Bahamas), and focus species conservation efforts there	7

Pine rocklands – Priority Adaptation Strategies sorted by Sum		
Rank	**Action**	**Selections**
7	Increase elevation of pine rocklands through substrate addition to keep pace with SLR	6

The top three adaptation actions for pine rocklands (Table 1.1) received equal scores from the workshop participants. These three selections point to the need for much deeper discussions on managing for change, assisted migration, and persistence management. The highest ranked action is a managing for change strategy that would allow pine rocklands to be replaced by another natural habitat type. This action is aimed at embracing change to suit current and future climate conditions, while transitioning away from the current habitat that may no longer be viable under those same conditions.

The second highest ranked action follows the concept of assisted migration. While assisted migration is often used to reference the relocation of a single species, this action is aimed at the recreation of an entire habitat and its associated community in a new location. Location of this newly created habitat would be informed by elevation data to ensure its long-term viability when considering sea level rise.

Finally, the third highest ranked action can be considered persistence management. In this instance, the habitat will be conserved in its historic conditions until this is no longer possible at which point, the habitat will either become completely extirpated, or transition to a salt tolerant community. These three adaptation actions generate three very different futures for pine rocklands and their associated communities and require a thoughtful examination.

After priorities actions were established, we selected the strategy “Increase elevation of pine rocklands through substrate addition to keep pace with sea level rise” for our barrier exercise. While this action received the least number of votes, we felt this action as an introduction may better prepare participants to discuss a wide array of barriers. Through MeetingSphere, we asked participants to outline all potential conceived barriers utilizing the STAPLEE method categories.

Examples of identified barriers under each category are listed below

Social

- People/built environment will need limestone fill as well. Some may say, "Why are you fooling with the woods while our roads, homes, businesses are at risk?"

Technical

- The "original" substrate is more than just rubble. How do you recreate the drainage and characteristics of the limestone substrate?

Administrative

- Might staff time and resources be better spent on higher-impact and better developed activities?

Political

- Constituents may prefer other, more visible or higher impact activities to address sea level rise

Legal and Governance

- Would require modification with heavy machinery within endangered species habitat and potentially cause "take" of listed species

Economic

- likely expensive for a short-term solution

Environmental

- All the different species (insect, etc.) that interact with the rocklands may not respond the same way to the elevation and the introduction of the substrate

For the three case study species, participants were broken into 3 groups to repeat the exercise previously completed for pine rocklands. However, instead of stopping at barrier identification, participants were given the chance to determine how to overcome those barriers. Responses to these barriers ranged from public support methods, internal agency adjustments, and changes in environmental laws. Each barrier may require multiple players and approaches, as there are no one-size-fits-all solutions. Finally, participants prioritized barrier solutions based upon expected efficacy and importance.

During a lunch panel, members of TNC, FWS, and NPS were assembled to discuss their emerging roles in managing under a changing climate, and their ability to execute their directives as habitats are overtaken by rising seas. We first discussed when an agency might allow for extinction, and what role their agency would take. Following the panel, we met in plenary to take a wider perspective of the field of adaptation, and the applications that may result from this workshop. Some of the concepts of this session included changes in natural resource management expectations in human develop systems, retreating management from areas taking great loss, and continuing to advance adaptation within a shifting political system.

6.3 RESULTS

The results of Workshop 3 consisted of species-specific discussions of adaptation actions, barriers to implementing them, and methodologies to overcome those barriers. Due to the limited time of Workshop 3, not all adaptation actions were evaluated for barriers or methods to overcome them. For each species, participants outlined barriers to 2-3 proposed adaptation actions. These barriers were then prioritized and the top 5-6 were reviewed. Possible methods to overcome each barrier were proposed, and then prioritized in order of important or efficacy. Below, the lower Keys marsh rabbit provides an example of the workshop results. Results for pine rocklands, the Miami blue butterfly, and the Keys tree cactus can be found in Appendix 7 (pine rocklands), Appendix 8 (Miami blue), and Appendix 9 (tree cactus). The full results for the marsh rabbit can be found in Appendix 10.

6.3.1 THE LOWER KEYS MARSH RABBIT (*SYLVILAGUS PALUSTRIS HEFNERI*)

Provided in the table below (Table 1.2) are examples of climate adaptation actions intended to prevent extinction of the Lower Keys marsh rabbit. These specific adaptation actions were selected to provoke conversation on barriers to implementing adaptation actions. The top consideration determined during workshop 3 was assisted migration into managed land in the upper Keys from the lower Keys.

Table 1.2. Lower Keys Marsh Rabbit Action Rating. This table illustrates the priorities or workshop 3 participants. Each participant was asked to select their top three choices.

Lower Keys marsh rabbit - Adaptation Strategies	
Rank	**Item**
1	Assisted migration from Lower Keys to Upper Keys
2	Increase predator control, particularly on wildlife management areas - cats, pythons
3	Assisted migration to managed lands in south Florida (allowing/planning on hybridization with mainland subspecies)
4	Leverage money to spend on military infrastructure to conserve and improve LKMR habitat
5	Restore freshwater regimes to improve marsh habitat for LKMR, prioritized based on critical habitat and potential impacts.
6	Create wetlands on areas of new infrastructure, raised in elevation in response to SLR (e.g., military lands)
7	Fill in mosquito ditches - prioritize based on locations of critical habitat

This section shows all barriers identified by participants for three strategies related to the Lower Keys marsh rabbit. All barriers are classified based upon the STAPLEE method. While it wasn't the top priority adaptation strategy, we chose to discuss priority #3 "Assisted migration to managed lands in south Florida (allowing/planning on hybridization with mainland subspecies". The information outlined below represent perceived barriers for this strategy outlined by Workshop 3 participants.

Social

- perception of us playing God
- Social value for the species might be diluted by hybridization
- Public not wanting the species in their backyard
- Which agency takes public responsibility for assisted migration?
- Focus on a single species might make it harder to get people to take an ecosystem focus
- NGOs or individuals might act on assisted migration if we don't

Technical

- Might cause both the mainland and Keys species to become less fit or more fit (hybrid vigor)
- Are we able to catch the animals to move them? If so, will it cause so much stress from the event that they get sick or die

Administrative

- The organization who implements may deal with potential backlash (lots of calls and emails from the public).
- Seems like an extremely complex administrative strategy – i.e. lots of red tape

Political

- Will political capital be there and is this the "right" species to use it on?
- Not wanting to be the one to authorize translocation when there might be more important things (e.g., in the public's eyes) to spend funds on.
- Finding a political champion might be difficult. There are long-term implications with ESA classifications with hybrid spp.
- Sufficiently flexible rules/regs for multiple agencies to allow translocation into preferable lands

Economic

- Potentially costlier compared to in-situ action.
- Costs associated with additional expertise. e.g., vets, animal welfare, outreach/education, local governments and public in new location.
- Risk that money could be ill spent given the increase in predators on the mainland (e.g. pythons).

Environmental

- Risk of hybridization.
- Loss of subspecies.
- Impact on the managed lands that they move to.
- Does the habitat exist on the mainland and will it also be affected equally with climate change/SLR?
- Risk of new diseases, predators, etc. in new area.
- Will moving them save them, or put them at further risk from new predators. I.e. pythons.
- Translocation may not release predatory pressures from feral and outdoor cats (feral cats are everywhere)
- Will we reach a goal in the FWS RECOVERY plan if we try this strategy? How do we measure that success?

After outlining barriers, participants prioritized barriers and then posed potential solutions to overcoming those barriers. For the sake of time we chose to examine two barriers for this strategy: The risk of hybridization, and the risk of new diseases, predators, etc. in the new area. Some of the proposed methods were proposed to circumnavigate barriers while others suggested changing course all together. The results of this exercise are outlined below.

Risk of hybridization

- Translocate to marsh rabbit free zone (e.g., The Bahamas)

Lower Keys Marsh Rabbit *(Sylvilagus palustris hefneri)*

Proposed Action: Assisted migration to managed lands in south Florida (allowing/planning on hybridization with mainland subspecies)

Barriers to Implementation

- **Concerns that may cause both species to become less fit (Or more fit due to hybrid vigor)**
- **There are long-term implications with ESA classifications with hybrid *spp.***
- **Risk of poor adaptation to new diseases, predators, etc. in new area**

Once barriers were identified, participants voted electronically for the most critical barriers to overcome. For the marsh rabbit, a top barrier for translocation to the mainland focused on the risk of hybridization. Listed below are some examples of potential ways to overcome this barrier.

Risk of hybridization

- Translocate to marsh rabbit free zone (e.g., The Bahamas)
- Identify suitable habitat on mainland and remove all existing marsh rabbits and establish barriers to keep mainland marsh rabbits out.
- Remove federal protection for all translocated individuals to reduce legal bureaucracy associated with restrictions on hybridization

For a complete examination of marsh rabbit barriers including STAPLEE scoring, please see Supplemental Information Table S-1.

- May result in hybrid vigor. May be more resilient in face of climate change
- Put them in zoos instead
- Identify suitable habitat on mainland and remove all existing marsh rabbits and establish barriers to keep mainland marsh rabbits out.
- Remove federal protection for all translocated individuals so it won't matter
- Sterilize the mainland population into which you are translocating them
- Do it as cheaply as possible so failure it is not as big a deal
- Translocate to another higher key w/o existing marsh rabbits
- Do studies on sexual selection and hybrid fitness to better understand implications

Risk of new diseases, predators, etc. in the new area

- Translocate them in suitable habitats cut off from other rabbits and other mammals so they have food and are free from outside contact!
- Predator exclusion
- Don't worry about it. Do it because we are seen to be doing something (potentially knowing it won't work) which allows them to go extinct without the risk of being sued
- Careful selection of introduction area including monitoring existing rabbit population for disease and fitness
- Put predator deterrents in introduction sites Institute or increase controls on predators in the introduction site
- Vaccinate translocated individuals
- Ensure habitat suitability is of high enough quality that their recruitment rates outpace loss thru predation

6.4 DISCUSSION

There is a universal recognition that conditions are changing and with this comes a reorganization of ecological community structure. How managers address this change will determine the success or failure of sustaining or enhancing ecological function and/or services. The group considered **<u>what managing for change means in the context of natural resource management</u>**. Managing for change for pine rocklands may mean allowing for, or assisting in, transition to tropical hardwood hammock (or other future suitable communities). It could also mean moving pine rockland endemics further inland to other pine forests (e.g. pine flatwoods).

The participants discussed the idea of managed retreat related to the abandonment of currently managed public lands. This concept involves **<u>exchanging protected public lands for new inland areas</u>** before they can be developed. For example, FWS could purchase and restore habitat on orange groves under stress rather than spending money in the Keys to manage lands that will inevitably be lost to sea level rise.

> **Managing for Change: An ongoing process of management of a natural resource with climate driven changes in mind, rather than as a fixed endpoint (Stein et al. 2013).**

Many ideas and discussions focused on the managing for natural resources in an urban environment, such as using roof tops for endangered plants, roof top gardens for butterflies, stray cat management, and incorporating priorities associated with societal priorities. These discussion points brought forward the concept that we might be seeing **a shift in the field of conservation from managing the natural environment to residential conservation.** For example, allowing property owners in diverse locations to cultivate endangered plants with narrow ranges reduces the risk of extinction from stochastic events or a changing climate.

While traditional conservation does not permit hybridization of distinct subspecies or species, this form of **assisted evolution may increase the likelihood of survival for those heading toward extinction.** Facing the complete loss of its native range, hybridization was highly considered for the Lower Keys marsh rabbit. Rather than lose a species entirely to extinction, facilitating hybridization between two species in part conserves the genetics of the endangered marsh rabbit. While this may be controversial for both the mainland and Keys species, the resulting combination may be better suited to the changing conditions in South Florida. This approach is already being examined for corals that are facing the effects of warming seas by expelling their symbiotic algae (van Oppen et al., 2015).

Another consideration focused on the concept of **'conserving the stage' rather than 'the actors'** (*sensu* Anderson and Ferree, 2010). This paradigm shift requires that natural resource managers primarily focus on conserving the diversity of geologies with secondary consideration of their biological components thus facilitating the ecological transition associated with a changing environment. The premise is that a diverse geoscape will support diverse biological communities thus addressing biodiversity-conservation priorities. This may keep the system "healthy" albeit perhaps with different ecological function and associated services.
Each of these ideas requires that managers think differently and embrace the uncomfortable reality that conditions are changing, and that they must manage for change rather than persistence. Ultimately their roles in conservation and management may evolve along with the changing landscape. When once they managed upland habitats and associated species, they may soon find themselves managing mangrove forest.

The natural resource managers of today and the near future will face more and more tough decisions that may have no ideal solutions. Hard questions must be pressed, and answers must be found. When do you abandon in-situ management of a species? If you do abandon it, how do you determine between ex-situ or extinction? Should we allow for extinction of species in disappearing habitats, or should we do everything within our power to prevent it?

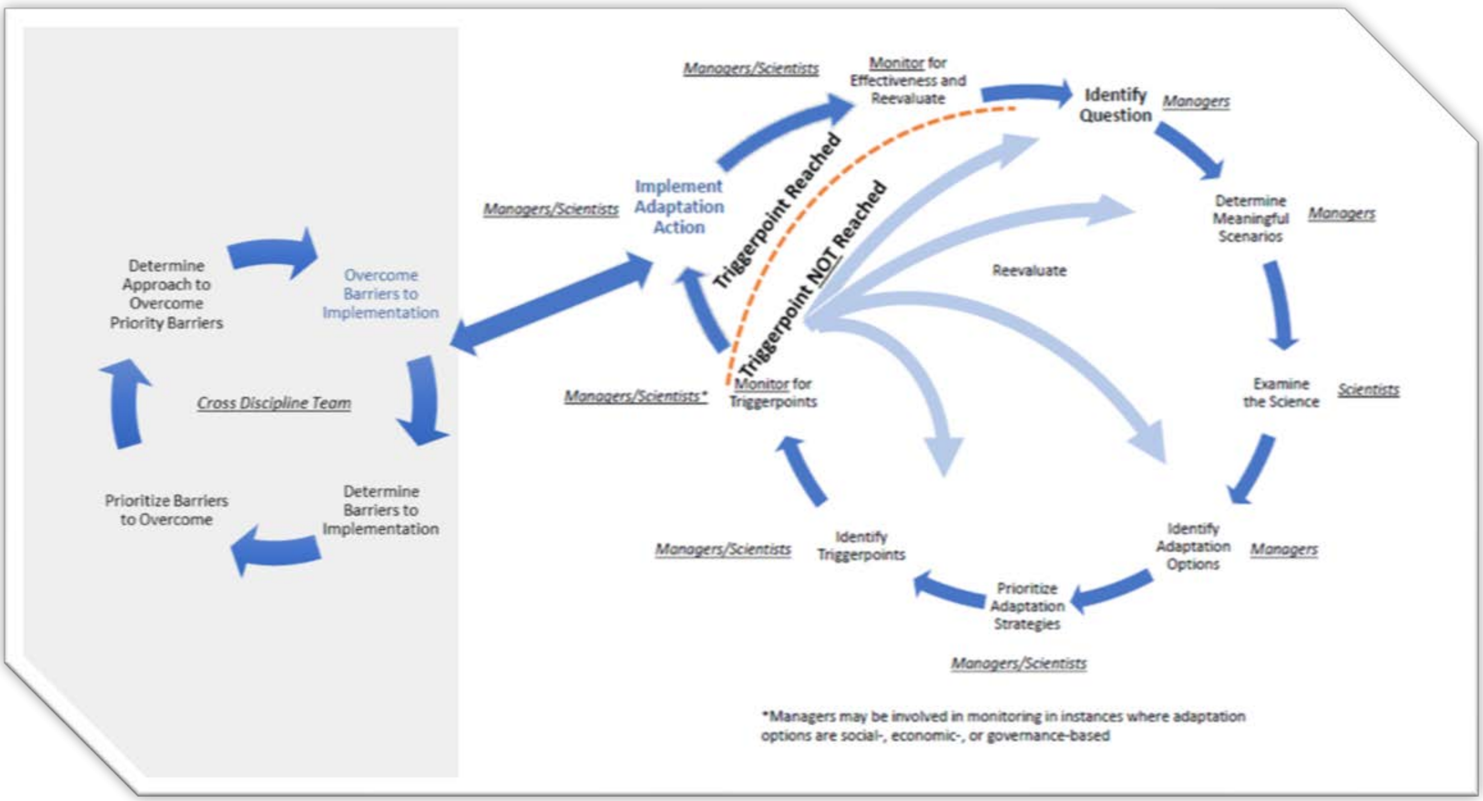
6.5 CONCLUSIONS

Some of the important take-away messages from this project are as follows. Many of these are directly applicable to projects with similar goals that are beyond the Florida Keys region.

- **Natural resources managers face many barriers to implementing climate adaptation actions.** While natural resource managers may be able to tackle some of these barriers within their own agencies or managed lands, others will require local stakeholder buy in, large societal changes, or even changes in federal or state laws.

- **There is a need to build materials and networks to share methodologies to overcoming barriers and lessons learned.**

- **Inclusion of experts from multiple backgrounds is necessary because barriers arise from multiple arenas.**



6.5.1 PLANNING CYCLE UPDATE

To assist others in developing adaptation plans and overcoming barriers to those plans, we determined that our planning approach required an addendum. While updating our approach does not provide the end user with all the answers, it should give them a methodical way to implement their actions without the surprise of barriers. Not being prepared for barriers to your actions will likely end in delays, or even cause you to miss a grant or planning cycle.

Suggested steps to add include:

1. Determine Barriers to Implementation
2. Prioritize Barrier to Overcome
3. Determine Approach to Overcome Priority Barriers

4. Overcome Barriers to Implementation

These steps would follow the prioritization of adaptation strategies and be put in motion prior to reaching trigger points. This allows for the immediate implementation of strategies once trigger points are reached. For each added step of the cycle we recommend the assembly of a team of cross-discipline experts to provide insight into barriers to implementation. Ideally these experts provide insight into potential social, technical, administrative, political, legal, economic and environmental barriers to implementing an action. If a group of experts cannot be assembled, their input should still be solicited remotely.

Finally, we worked to develop next steps for our project. Some examples are listed below.

6.5.2 NEXT STEPS

ACTIONS
Integrate into existing work plans (e.g., the FWC imperiled species management plans)
Start implementing! Overcome the urge delay due to perceived or real barriers. (e.g., use a climate adaptation plan and get on-the-ground projects rolling)
Create a list of common barriers and how to overcome them that have broad applicability in a variety of national and international settings
Develop a set of examples that can serve as case studies of how to run the process of identifying barriers and how to overcome them
Work with funding entities to ensure that projects are supported that have the flexibility required for effective adaptive management
Influence future RFPs to focus on climate adaptation implementation (e.g., a FWC State Wildlife Grants project implementing adaptation strategies for Species of Greatest Conservation Need)

7. PROJECT TEAM

Bob Glazer |Florida Fish and Wildlife Conservation Commission
Robert Glazer is a Research Scientist with the Florida Fish and Wildlife Conservation Commission where he serves as the Climate Change Research and Monitoring Workgroup leader. He also serves as the Chair of the Monroe County Climate Change Advisory Committee, a committee that is tasked with making recommendations to the Board of County Commissioners on adaptation options. He has served as co-PI with MIT for a project developing climate adaptation plans for species and habitats in the Florida Keys marine environment and served as PI on a number of marine climate adaptation planning projects. He participated in developing the National Fish, Wildlife and Plants Adaptation Strategy. In 1994 he received the first Florida Jaycees Outstanding Young Environmentalist Award, and in 2006 he received the Southeastern Association of Fish and Wildlife Agencies Fisheries Biologist of the Year award, both in recognition of his work to restore south Florida queen conch population. In 2016, he received an Honorable Mention for the Climate Adaptation Leadership Award sponsored by the National Fish, Wildlife, and Plant Climate Adaptation Strategy's Joint Implementation Working Group in the State/Local category. In 2018, he received the FWC/FWRI Director's Award. Since 2004, Bob has served as Executive Director of the non-profit Gulf and Caribbean Fisheries Institute.

Steve Traxler | U.S. Fish and Wildlife Service
Steve works for the US Fish and Wildlife Service as a Senior Fish and Wildlife Biologist. Steve has been working on Everglade's restoration since 1996. Since 2011, he has been coordinating science for the Peninsular Florida Landscape Conservation Cooperative. Steve's other projects include Everglades RECOVER (System wide evaluation, monitoring and adaptive management team) and climate change. Previously, he has worked on Everglade's restoration projects on the estuaries such as the Indian River Lagoon, Florida Bay, and Biscayne Bay. Steve also works with a local marine conservation non-profit focused on sea turtle research and education called Inwater Research Group, Inc. His degrees are from Florida Institute of Technology (Bachelors) and a Masters in fisheries from Texas A & M University. His main hobbies include fishing, scuba diving, canoeing, kayaking, and hiking.

Chris Bergh | The Nature Conservancy
Chris Bergh was raised in the Florida Keys and studied environmental conservation in Florida and Arizona prior to beginning a career that has run the gamut from nature preserve management to urban conservation strategy development. In 2005 he helped initiate the Florida Reef Resilience Program (FRRP), an interdisciplinary partnership among coral reef managers, scientists, other NGO's and businesses designed to help Florida's reefs and reef-dependent people cope with climate change impacts, and he has overseen the Conservancy's partnership-based coral reef restoration efforts. In 2013 he helped launch and now leads the Southeast Florida Regional Climate Change Compact's Shoreline Resilience Working Group which is focused on identifying opportunities for natural or nature-based coastal defenses for one of the United States' most vulnerable regions with respect to hurricanes and sea level rise. He led the Conservancy's early and ongoing work on sea level rise vulnerability analysis for the Florida Keys and is overseeing the development of on-line decision support tools that help people in the Keys and Southeast Florida's urban areas look beyond their vulnerability to the nature-based solutions for reducing that vulnerability. Chris serves on the Southeast Florida Regional Climate Change Compact's Staff Steering Committee.

Beth Stys | Florida Fish and Wildlife Conservation Commission
Beth Stys is a Research Administrator for the Florida Fish and Wildlife Conservation Commission. She has worked for the FWC for over 24 years. Her work with FWC has focused on landscape level, statewide conservation planning, imperiled species protection, terrestrial and freshwater aquatic conservation area identification and prioritization, species habitat modeling, land cover mapping, and climate change. She is an instructor for the USFWS Climate Change Vulnerability Assessment and the Climate Smart Conservation classes. Beth is involved with all three Landscape Conservation Cooperatives in Florida, recently serving a 2-year term as Steering Committee Chair for the South Atlantic LCC and since August 2014, serving as co-Science Coordinator for the Peninsular Florida Landscape Conservation Cooperative.

Dr. Jason Evans | Stetson University

Dr. Jason M. Evans is Associate Professor of Environmental Science and Studies at Stetson University and Co-Editor-in-Chief for the Journal of Environmental Management. Trained as a landscape and systems ecologist, most of Evans's recent and current research focuses on sea-level rise and climate change adaptation in the southeast United States. He was the lead author for the Tybee Island Sea-Level Rise Adaptation Plan and the lead technical modeler for Monroe County's GreenKeys! Sustainability Action Plan, both of which have received national attention for innovation in climate change research, outreach, and policy development. Other communities in which he has advised on sea-level vulnerability and planning include Islamorada and Satellite Beach, FL; St. Marys, Glynn County, and Liberty County, GA; Beaufort, SC; and Nags Head and Hyde County, NC. Evans received his Ph.D. (2007) and M.S. (2002) in Interdisciplinary Ecology from the University of Florida. He also holds a B.A. (1998) in Philosophy from New College of Florida.

Logan Benedict | Florida Fish and Wildlife Conservation Commission

Logan is a climate adaptation biologist for the Florida Fish and Wildlife Conservation Commission, where his work has been focused on climate adaptation planning. Logan previously worked in Floodplain restoration ecology where he focused on long term shifts in species, and how they relate to environmental and biological stressors. His recent projects have focused on scenario planning related to managed lands and species in the northern gulf coast of Florida spanning from Hernando county to St. Marks county, and the terrestrial systems of the Florida Keys. Logan Benedict received his bachelor's degree in zoology at Southern Illinois University Carbondale, and his master's in biology at the University of Illinois Springfield.

Lily Swanbrow-Becker | Florida Fish and Wildlife Conservation Commission

Lily Swanbrow Becker joined the Florida Fish and Wildlife Conservation Commission as the Climate Adaptation Coordinator in December 2016. She enjoys her role of working with staff and a broad network of conservation partners in supporting climate research, communication, planning, and on-the-ground adaptation projects. Prior to joining Florida Fish and Wildlife, Lily worked in curriculum development at Florida State University where she developed educational texts, lesson plans and interactive tutorials focused on topics covering conservation ecology and climate change. She graduated from the University of Michigan with a degree in Environmental Science in 2005 and received her Master's in Conservation Biology from Texas State University in 2012.

Molly Cross | Wildlife Conservation Society

Molly Cross, Ph.D., is the Director of Climate Change Adaptation for the Wildlife Conservation Society Americas Program. Her work focuses on bringing together scientists and conservation practitioners and decision makers to translate climate change science into on-the-ground climate-informed conservation actions. Molly is helping to lead climate change planning efforts involving diverse stakeholders at several landscapes across the Americas, focused on a range of targets from individual species to more complex ecosystems. She co-edited the book Climate and Conservation: Landscape and Seascape Science, Planning and Action, and co-wrote a guidebook and associated training course on Scenario Planning as a tool for climate change adaptation. Molly has contributed to several national climate change efforts including the U.S. National Climate Assessment, the Climate-Smart Conservation guide to climate adaptation, and the Association of Fish and Wildlife Agencies guidance on incorporating climate change into state wildlife action plans. She is the Science Advisor to the WCS Climate Adaptation Fund, which supports applied projects demonstrating effective interventions for wildlife adaptation to climate change. Molly got her Ph.D. in Environmental Science, Policy and Management from the University of California, Berkeley, where she studied ecosystem responses to climate warming and plant diversity loss in the Colorado Rocky Mountains.

Bruce Stein | National Wildlife Federation

Dr. Bruce A. Stein is Chief Scientist and Associate Vice President for the National Wildlife Federation (NWF). Dr. Stein is a scientific expert on biodiversity and wildlife conservation and is the author of numerous publications on conservation biology, endangered species, and climate change. He has spearheaded the development of a climate adaptation planning approach known as "climate-smart conservation", which have been widely adopted by natural resource managers in the United States and internationally. Dr. Stein has served as a scientific advisor to various government agencies, including the U.S. Department of Interior and Department of Defense, and is on the steering committee of the International Union for the Conservation of Nature's (IUCN) Climate Change Specialist Group. Prior to joining NWF, he helped establish the non-profit organization NatureServe, where he served as Chief Scientist, and he spent more than a decade as a senior scientist with The Nature Conservancy. A botanist by training, he received his bachelor's degree from the University of California, Santa Cruz, and his Ph.D. from Washington University, St. Louis and the Missouri Botanical Garden.

Gregor Schuurman | National Park Service
Gregor Schuurman is an ecologist with the National Park Service Climate Change Response Program, where he works with national parks and partners to understand and adapt to a wide range of climate change impacts. His work focuses on 1) incorporating climate projections into management and planning, 2) developing and synthesizing management-relevant science, 3) analyzing climate adaption options in the context of policy, and 4) tracking ongoing adaptation in the NPS.

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9. APPENDICES

APPENDIX 1. PROJECT PARTICIPANTS

This table contains the names and organizations of all workshop participants, and others who contributed to the project.

Participant Name	Organization
Alicia Betancourt	University of Florida IFAS
Alison Higgins	City of Key West
Alison Higgins	City of Key West
Beth Bergh	Monroe County
Bill Uihlein	US Fish and Wildlife Service
Brian Powell	US Fish and Wildlife Service
Brittany Harris	Florida International University
Bruce Stein	National Wildlife Federation
Craig Vanderheiden	The Institute for Regional Conservation
Danielle Ogurcak	Florida International University
Einat Sandbank	Florida Fish and Wildlife

Elsa Alvear	National Park Service
Erica Henry	North Carolina State University
George Garrett	City of Marathon
Geovanna Torres	City of Marathon
Hong Liu	Florida International University
Janice Duquesnel	Florida Park Service
Jeanette Parker	Florida Fish and Wildlife
Jeremy Dixon	US Fish and Wildlife Service
Jerry Lorenz	Audubon Society
Jon Oetting	Florida Natural Areas Inventory
Katherine Watts	US Fish and Wildlife Service
Kevin Kalasz	US Fish and Wildlife Service
Lily Swanbrow-Becker	Florida Fish and Wildlife
Mary Truglio	Florida Museum of Natural History

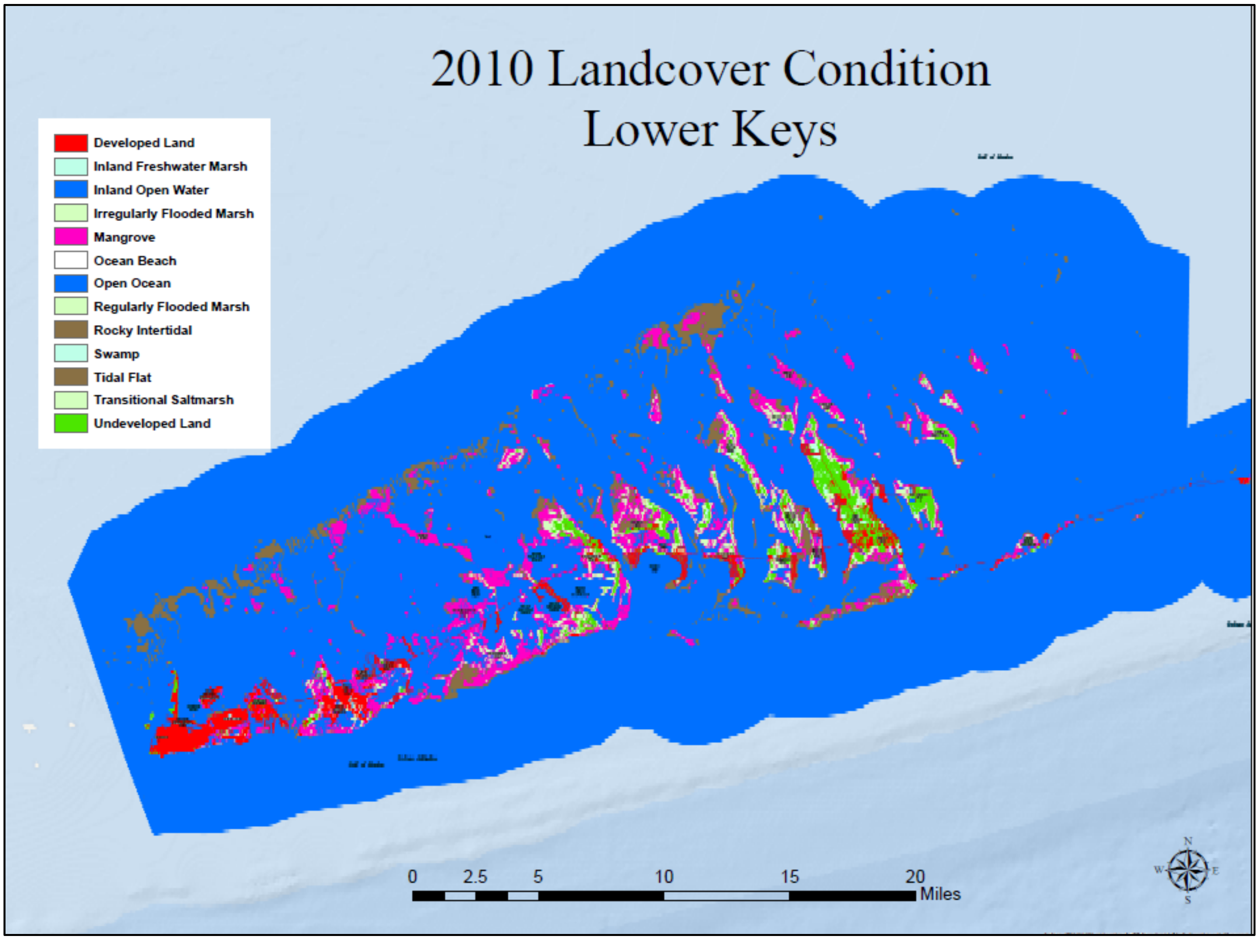
Matthew Martin	Florida Keys Navy
Meaghan Johnson	National Park Service
Meike de Vringer	Fairchild Botanical Gardens
Michael Roberts	Monroe County
Mike Cove	North Carolina State University
Mike Ross	Florida International University
Mikki Coss	Keys Mosquito
Paul Rice	Florida Park Service
Randy Grau	Florida Fish and Wildlife
Ricardo Zambrano	Florida Fish and Wildlife
Sandra Sneckenberger	US Fish and Wildlife Service
Sara Hamilton	Florida Keys Electric
Sarah Steele-Cabrera	Florida Museum of Natural History
Scott Tedford	Florida Park Service

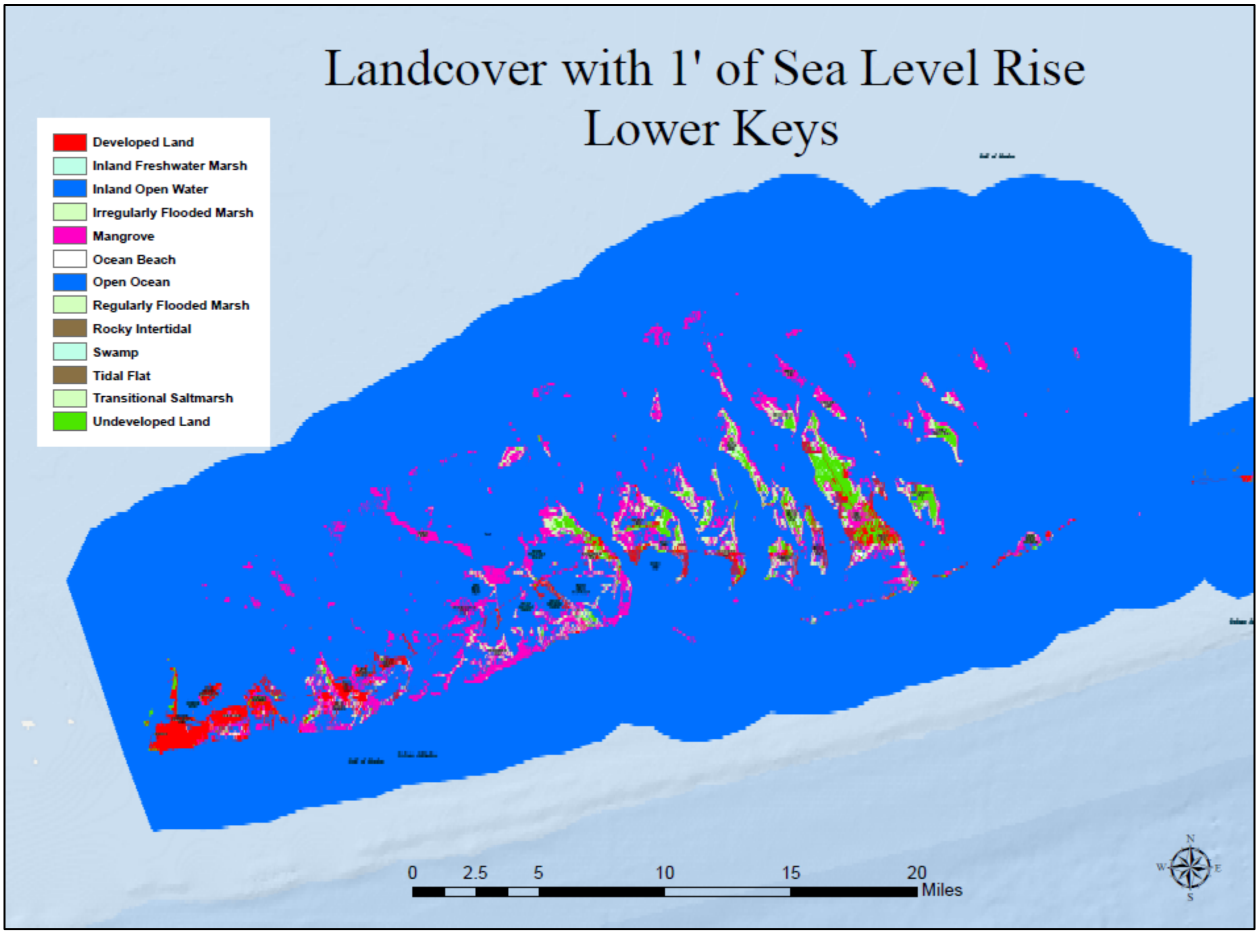
Steve Bradshaw	Keys Mosquito
T.J. Patterson	Florida Keys Electric
Todd Hopkins	Peninsular Florida LCC
Trudy Ferraro	Florida Park Service
Vanessa McDonough	National Park Service

APPENDIX 2. SEA LEVEL RISE AFFECTING MARSH MODEL RESULTS

This appendix contains SLAMM maps for 3 regions in the Florida Keys, upper, middle, and lower. There are 5 SLAMM maps for each region, 2010 (initial conditions), 1 foot, 2 feet, 3 feet, and 4 feet of sea level rise.

2.1 LOWER KEYS SLAMM




Landcover with 1' of Sea Level Rise
Lower Keys
Developed Land
Inland Freshwater Marsh
Inland Open Water
Irregularly Flooded Marsh
Mangrove
Ocean Beach
Open Ocean
Regularly Flooded Marsh
Rocky Intertidal
Swamp
Tidal Flat
Transitional Saltmarsh
Undeveloped Land
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Miles
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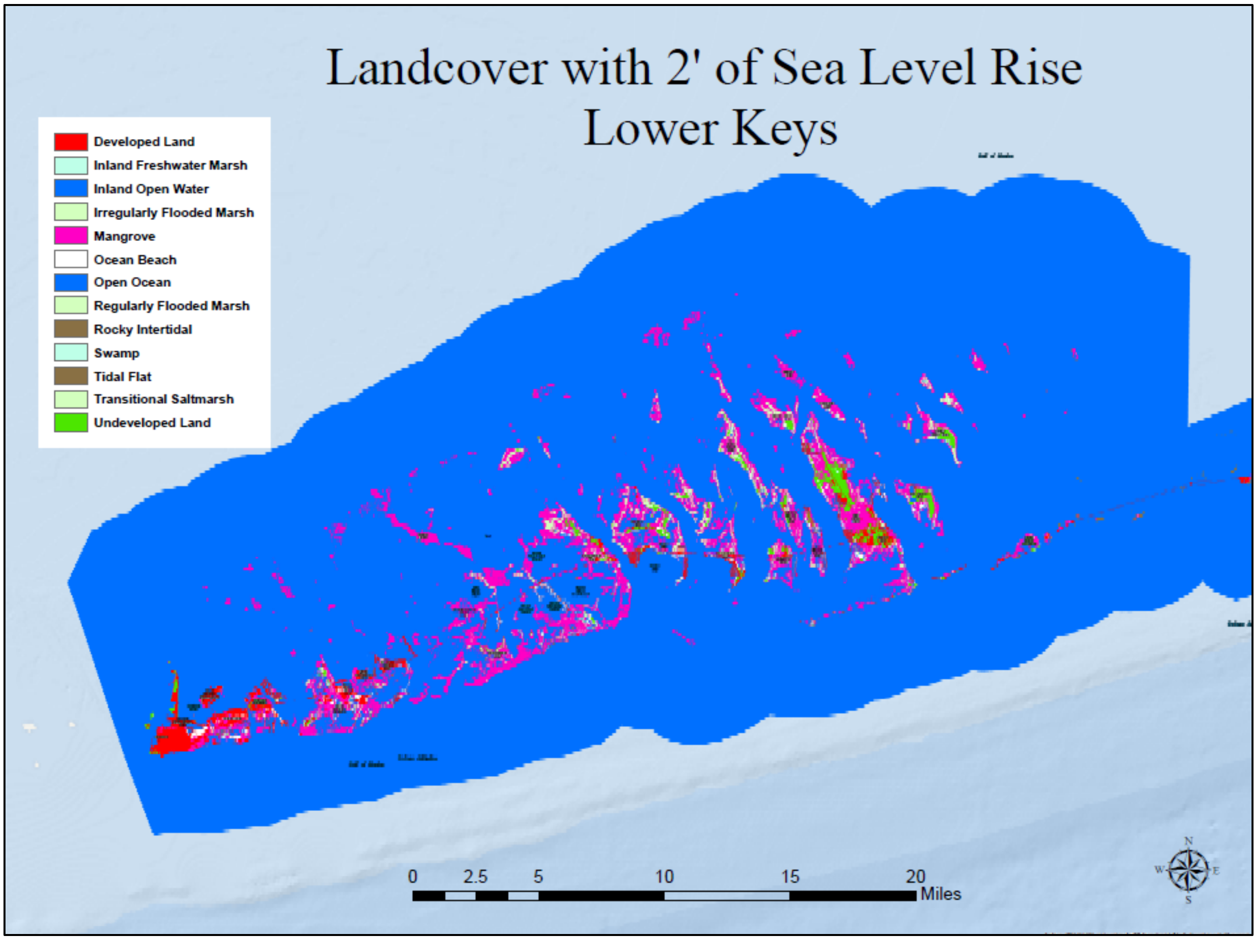
Landcover with 2' of Sea Level Rise
Lower Keys
Developed Land
Inland Freshwater Marsh
Inland Open Water
Irregularly Flooded Marsh
Mangrove
Ocean Beach
Open Ocean
Regularly Flooded Marsh
Rocky Intertidal
Swamp
Tidal Flat
Transitional Saltmarsh
Undeveloped Land
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Miles
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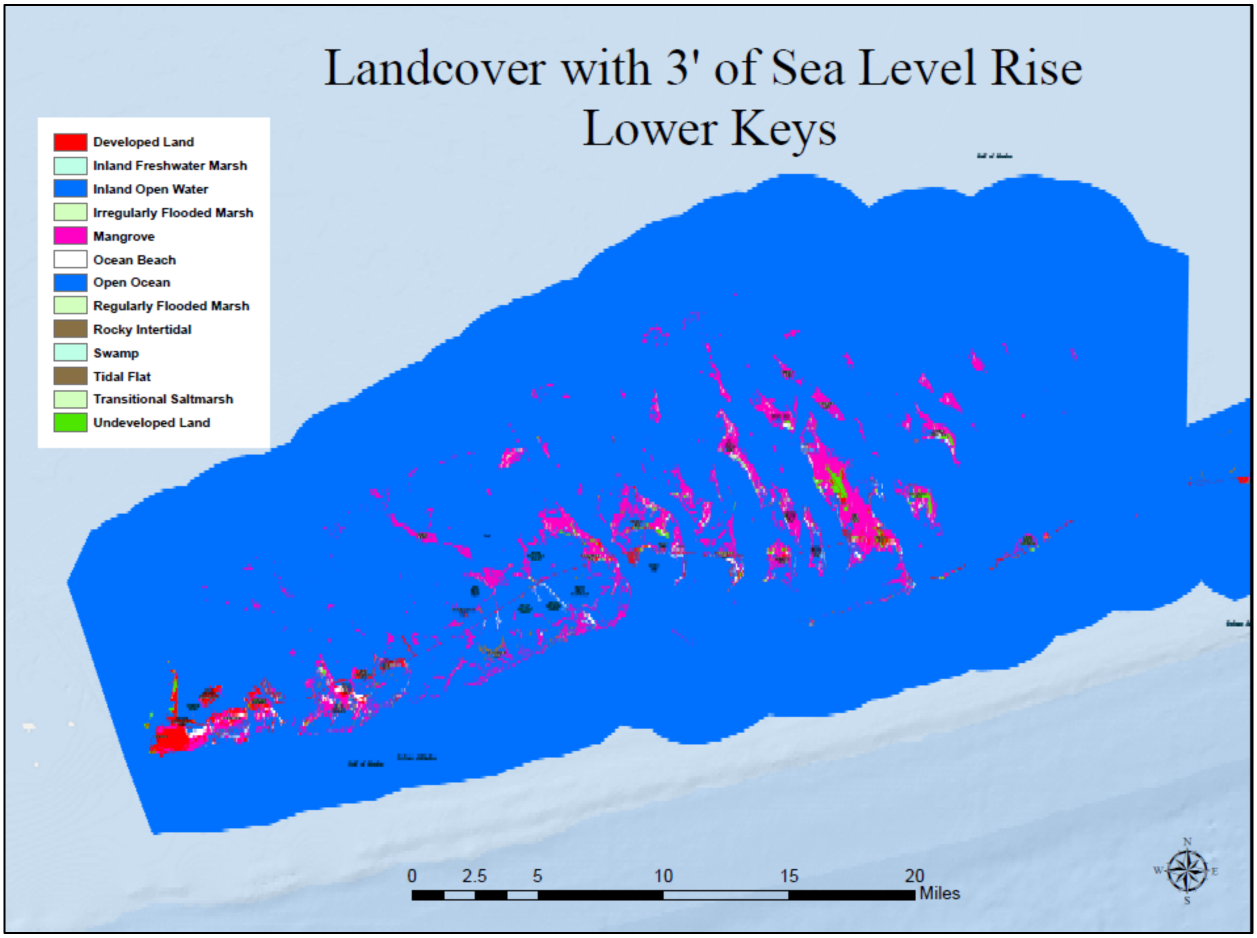
Landcover with 3' of Sea Level Rise
Lower Keys
Developed Land
Inland Freshwater Marsh
Inland Open Water
Irregularly Flooded Marsh
Mangrove
Ocean Beach
Open Ocean
Regularly Flooded Marsh
Rocky Intertidal
Swamp
Tidal Flat
Transitional Saltmarsh
Undeveloped Land
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Miles
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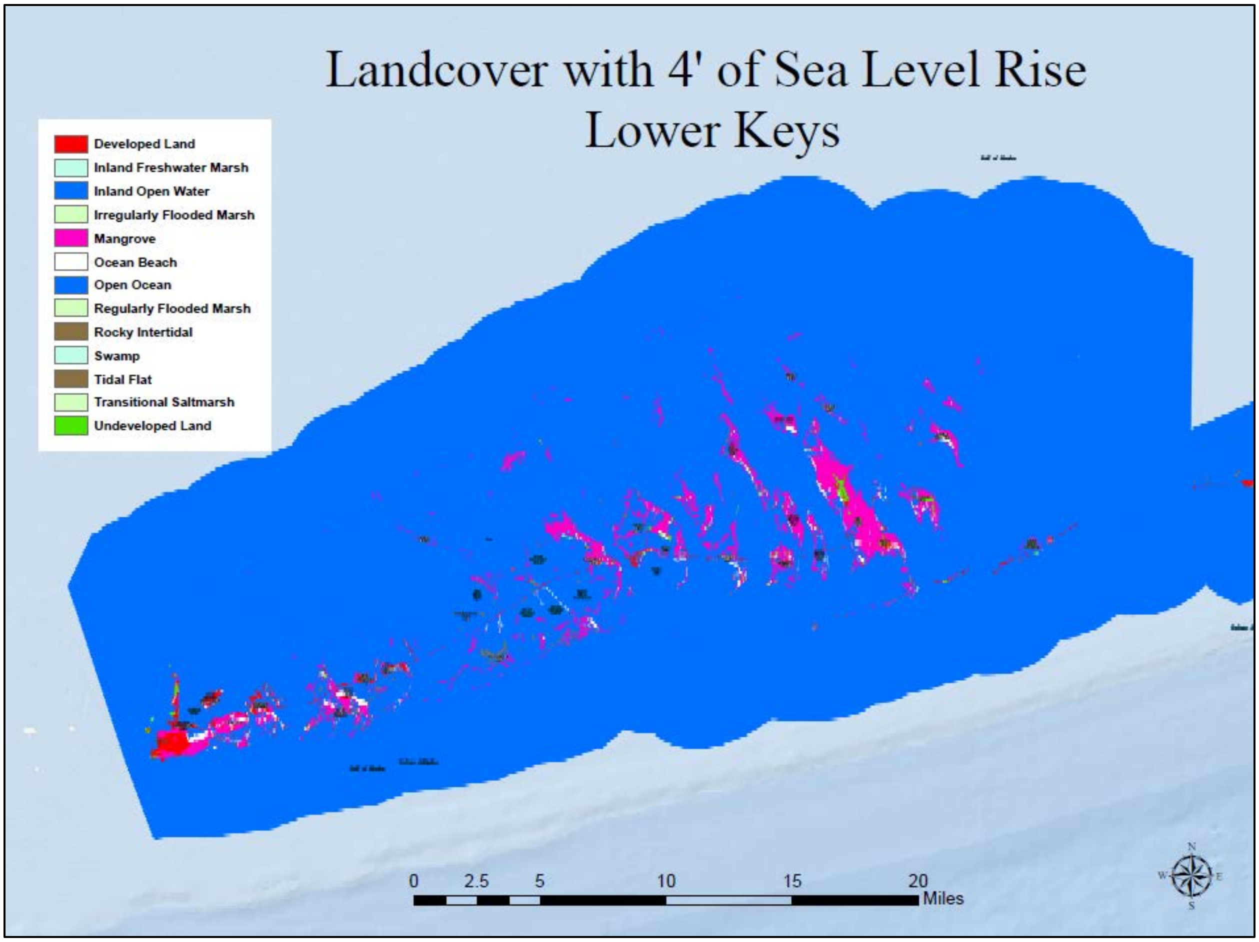
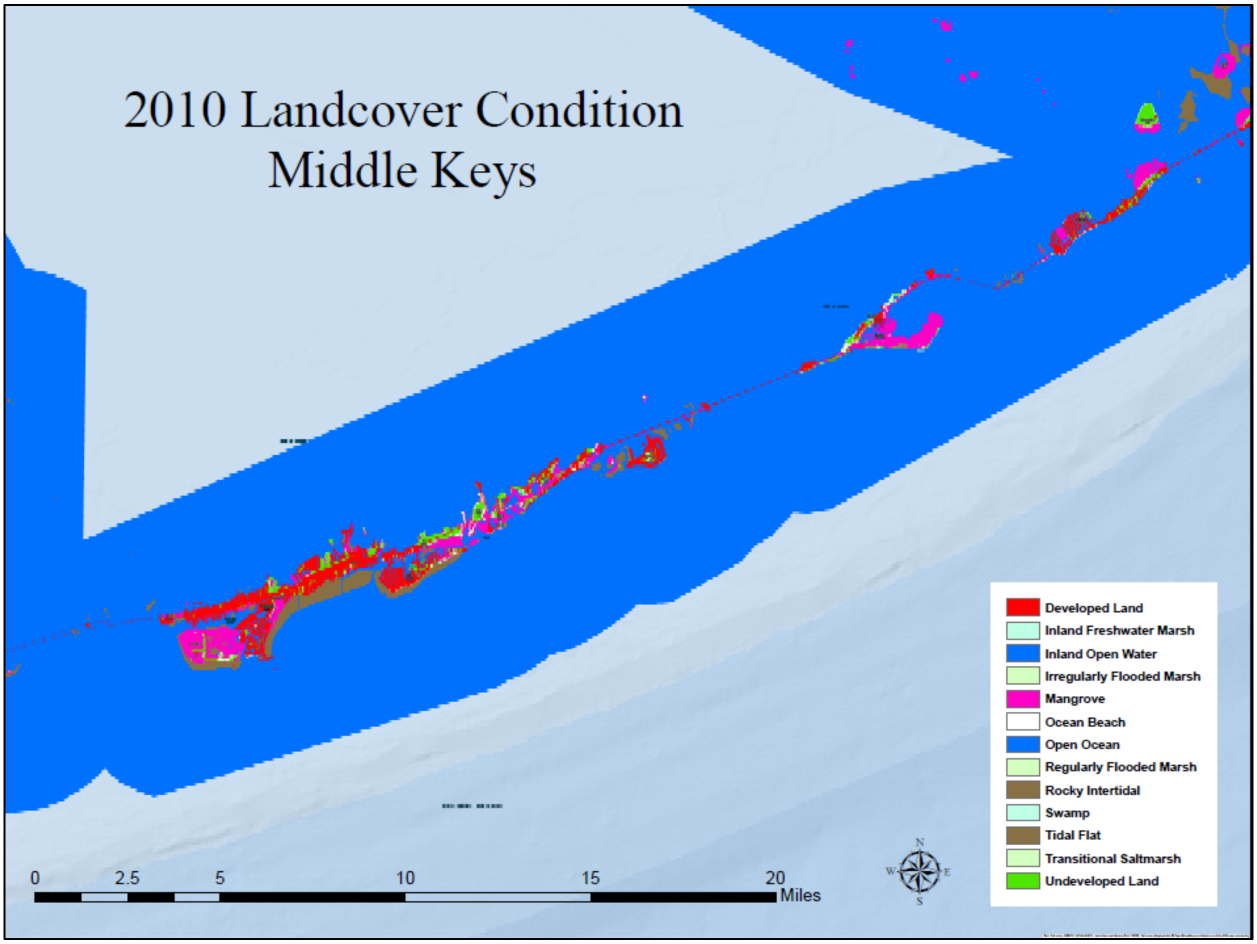


2.2 MIDDLE KEYS SLAMM


2010 Landcover Condition
Middle Keys
Developed Land
Inland Freshwater Marsh
Inland Open Water
Irregularly Flooded Marsh
Mangrove
Ocean Beach
Open Ocean
Regularly Flooded Marsh
Rocky Intertidal
Swamp
Tidal Flat
Transitional Saltmarsh
Undeveloped Land
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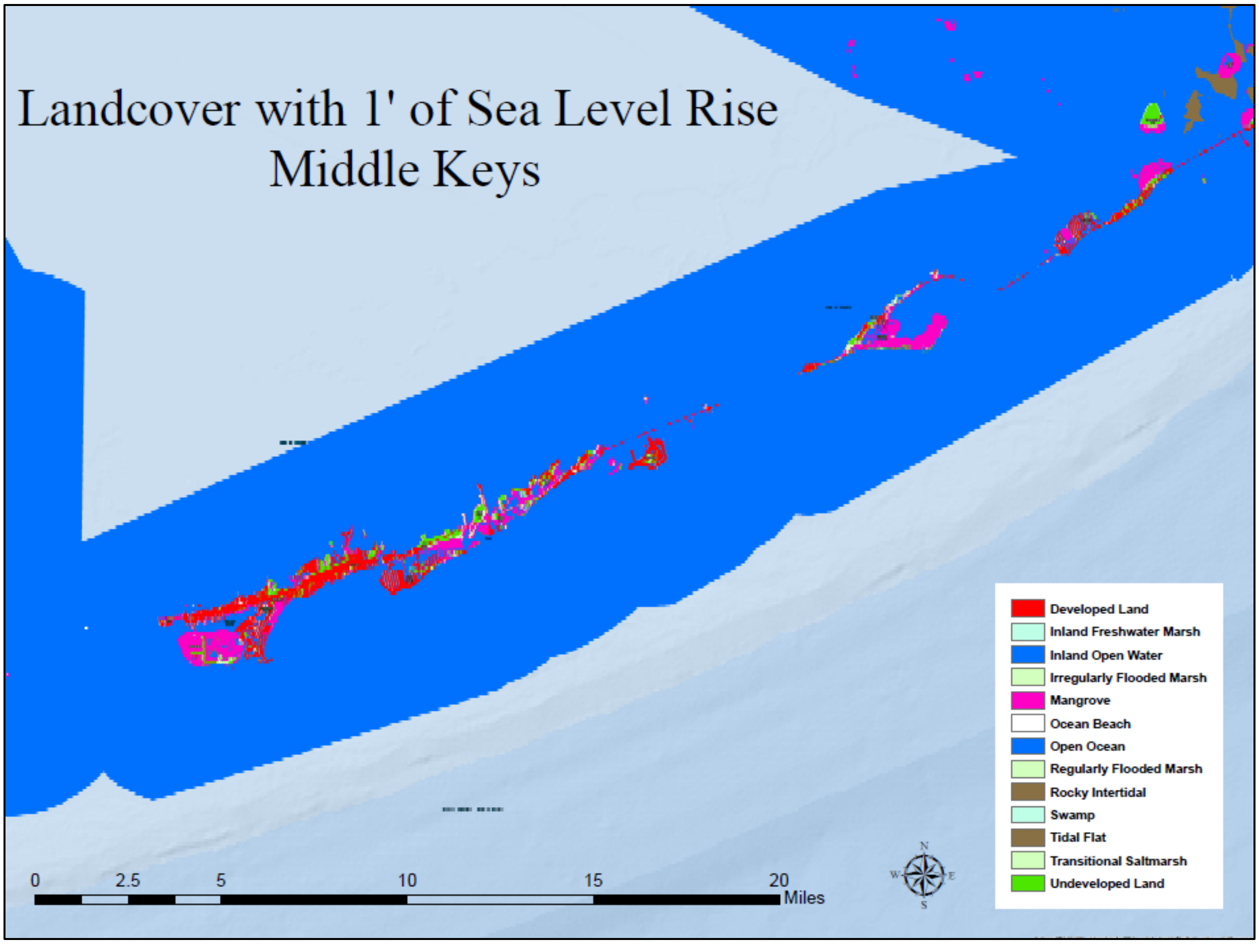
Landcover with 1' of Sea Level Rise
Middle Keys
Developed Land
Inland Freshwater Marsh
Inland Open Water
Irregularly Flooded Marsh
Mangrove
Ocean Beach
Open Ocean
Regularly Flooded Marsh
Rocky Intertidal
Swamp
Tidal Flat
Transitional Saltmarsh
Undeveloped Land
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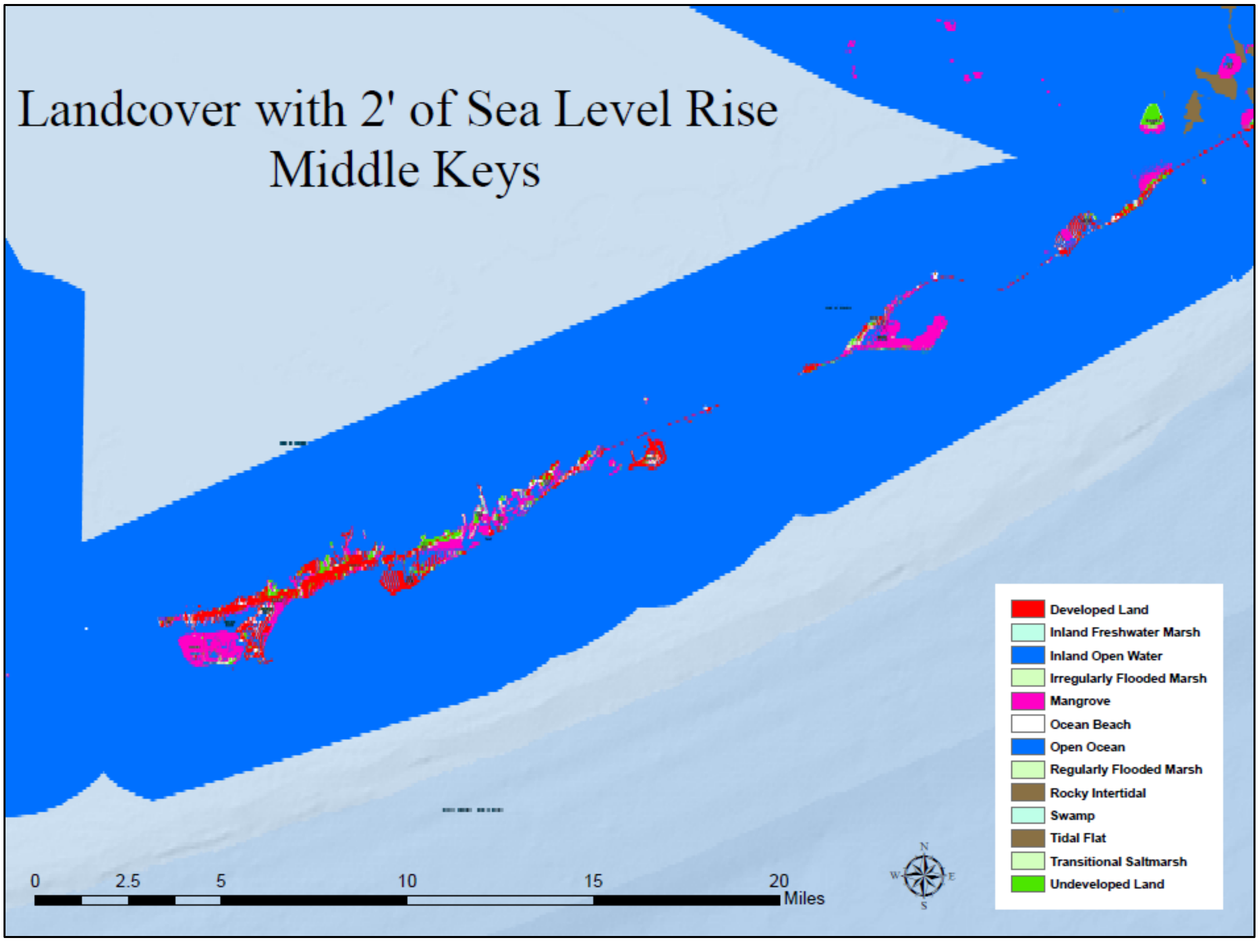
Landcover with 2' of Sea Level Rise
Middle Keys
Developed Land
Inland Freshwater Marsh
Inland Open Water
Irregularly Flooded Marsh
Mangrove
Ocean Beach
Open Ocean
Regularly Flooded Marsh
Rocky Intertidal
Swamp
Tidal Flat
Transitional Saltmarsh
Undeveloped Land
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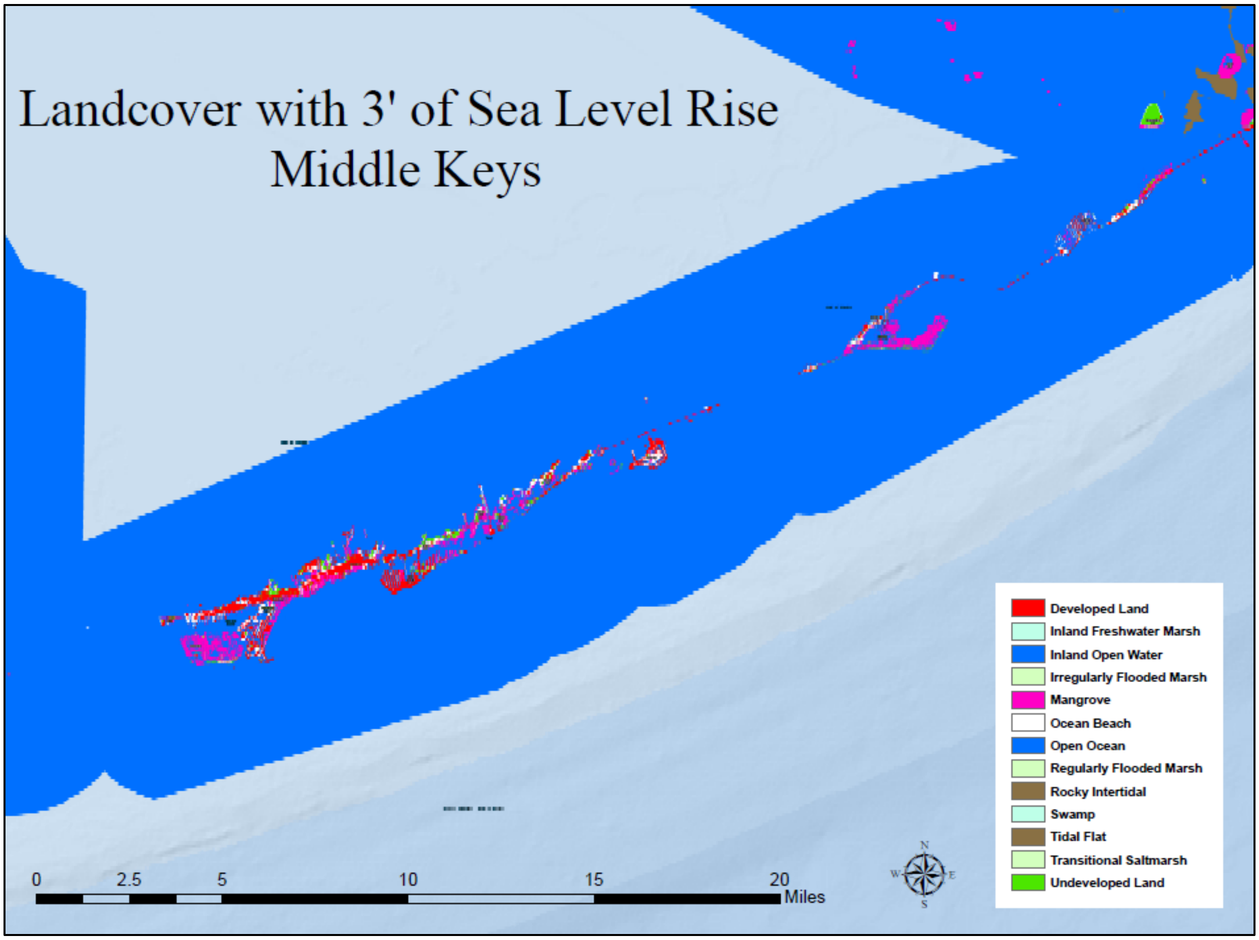
Landcover with 3' of Sea Level Rise
Middle Keys
Developed Land
Inland Freshwater Marsh
Inland Open Water
Irregularly Flooded Marsh
Mangrove
Ocean Beach
Open Ocean
Regularly Flooded Marsh
Rocky Intertidal
Swamp
Tidal Flat
Transitional Saltmarsh
Undeveloped Land
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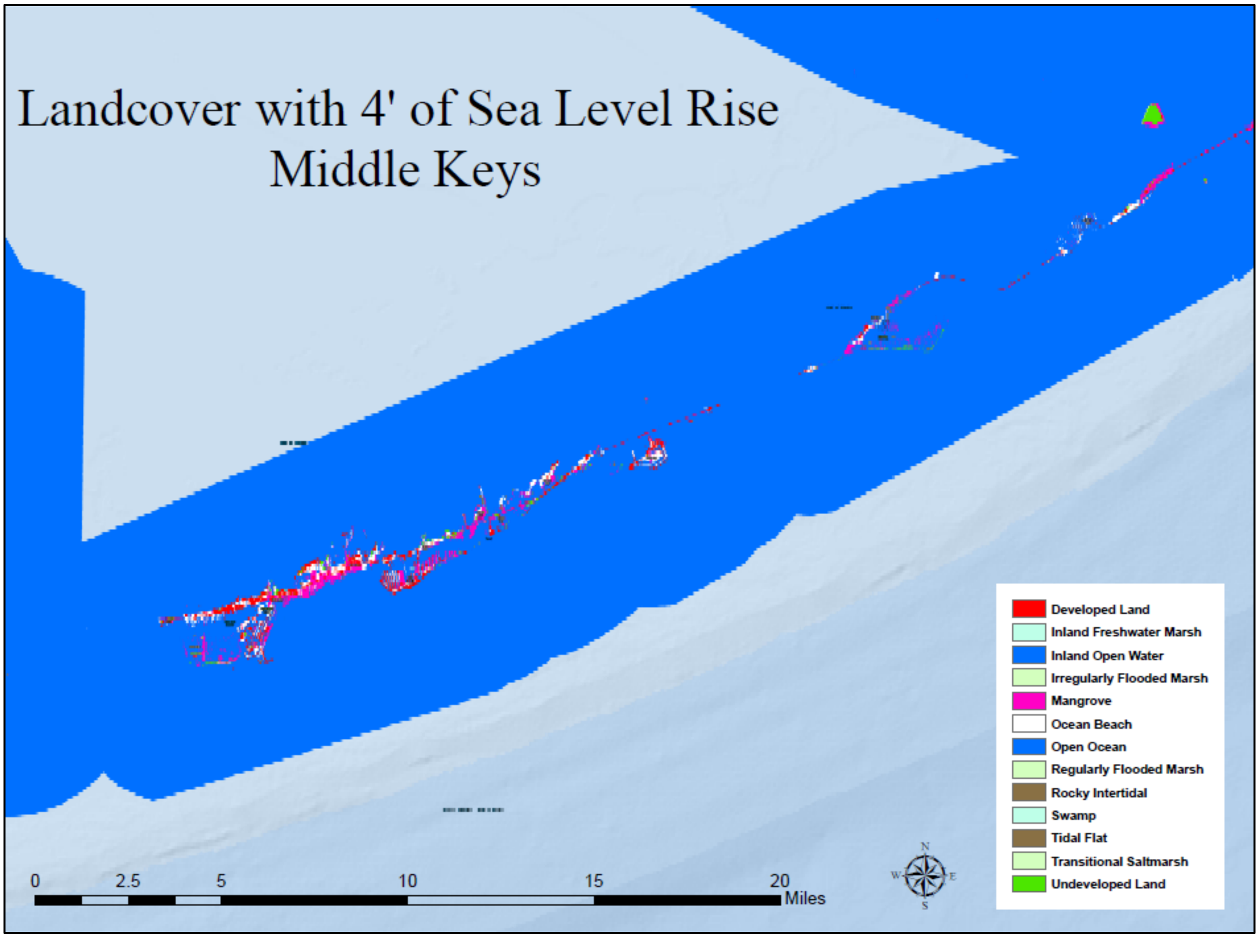
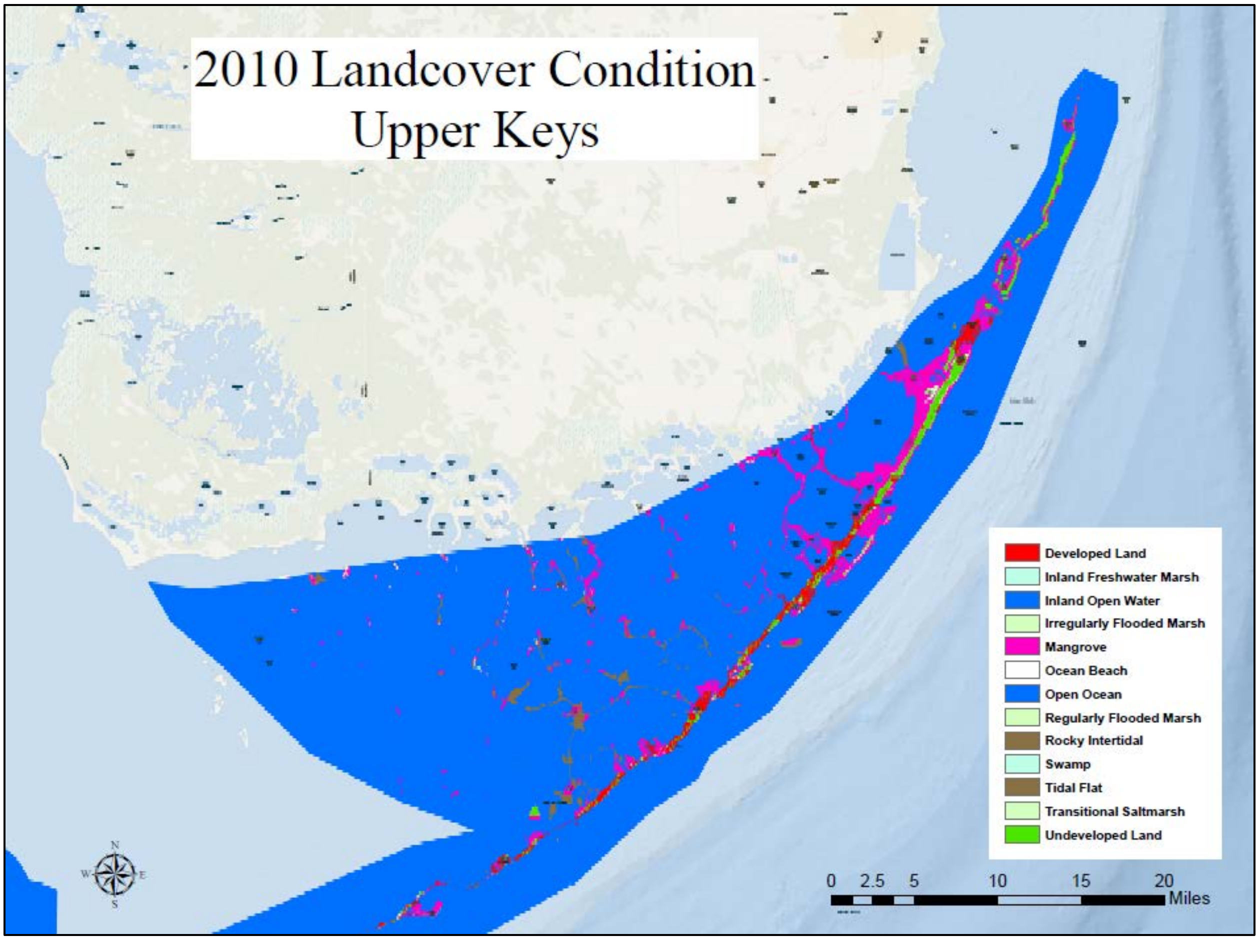


2.3 UPPER KEYS SLAMM


2010 Landcover Condition
Upper Keys
Developed Land
Inland Freshwater Marsh
Inland Open Water
Irregularly Flooded Marsh
Mangrove
Ocean Beach
Open Ocean
Regularly Flooded Marsh
Rocky Intertidal
Swamp
Tidal Flat
Transitional Saltmarsh
Undeveloped Land
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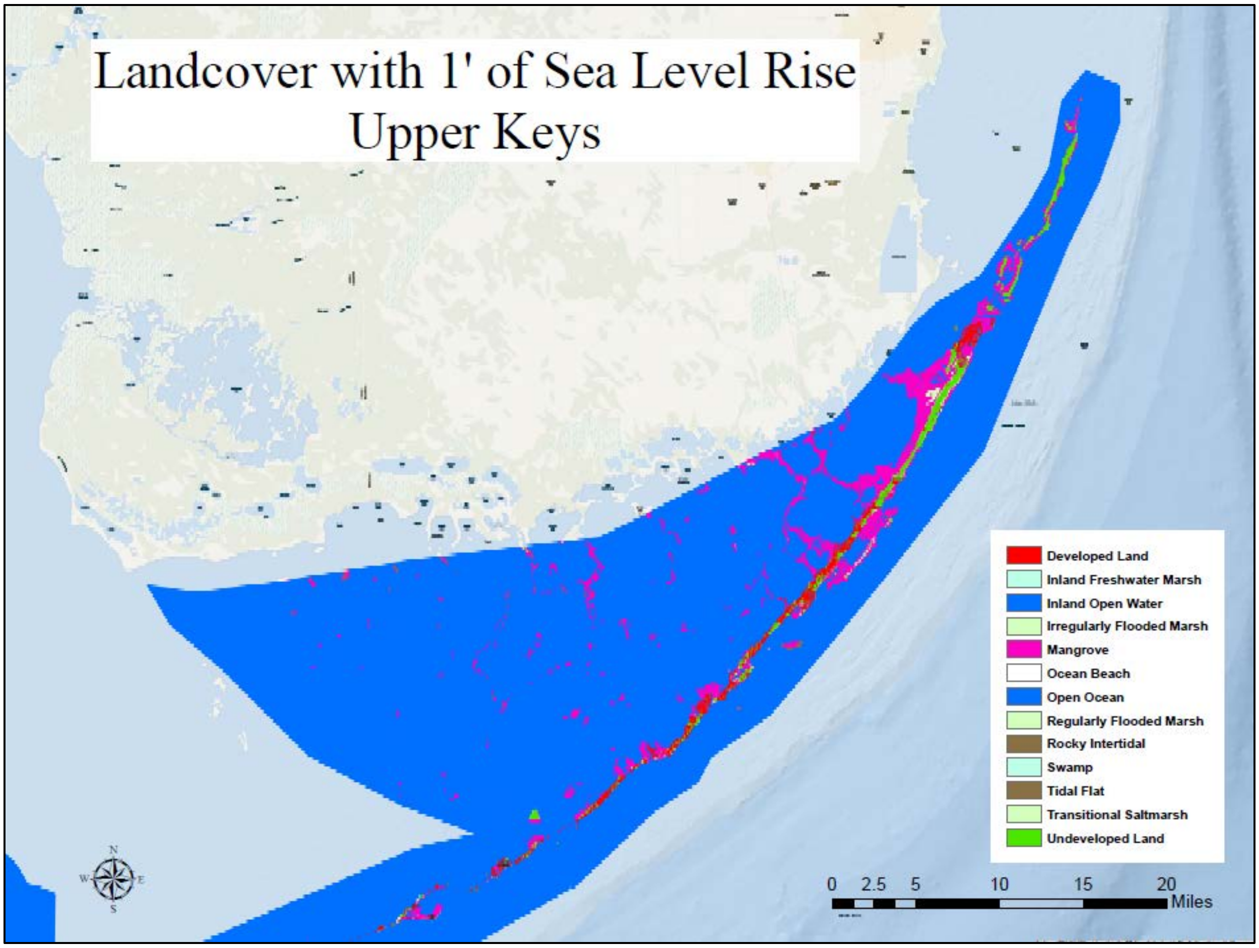
Miles


Landcover with 1' of Sea Level Rise
Upper Keys
Developed Land
Inland Freshwater Marsh
Inland Open Water
Irregularly Flooded Marsh
Mangrove
Ocean Beach
Open Ocean
Regularly Flooded Marsh
Rocky Intertidal
Swamp
Tidal Flat
Transitional Saltmarsh
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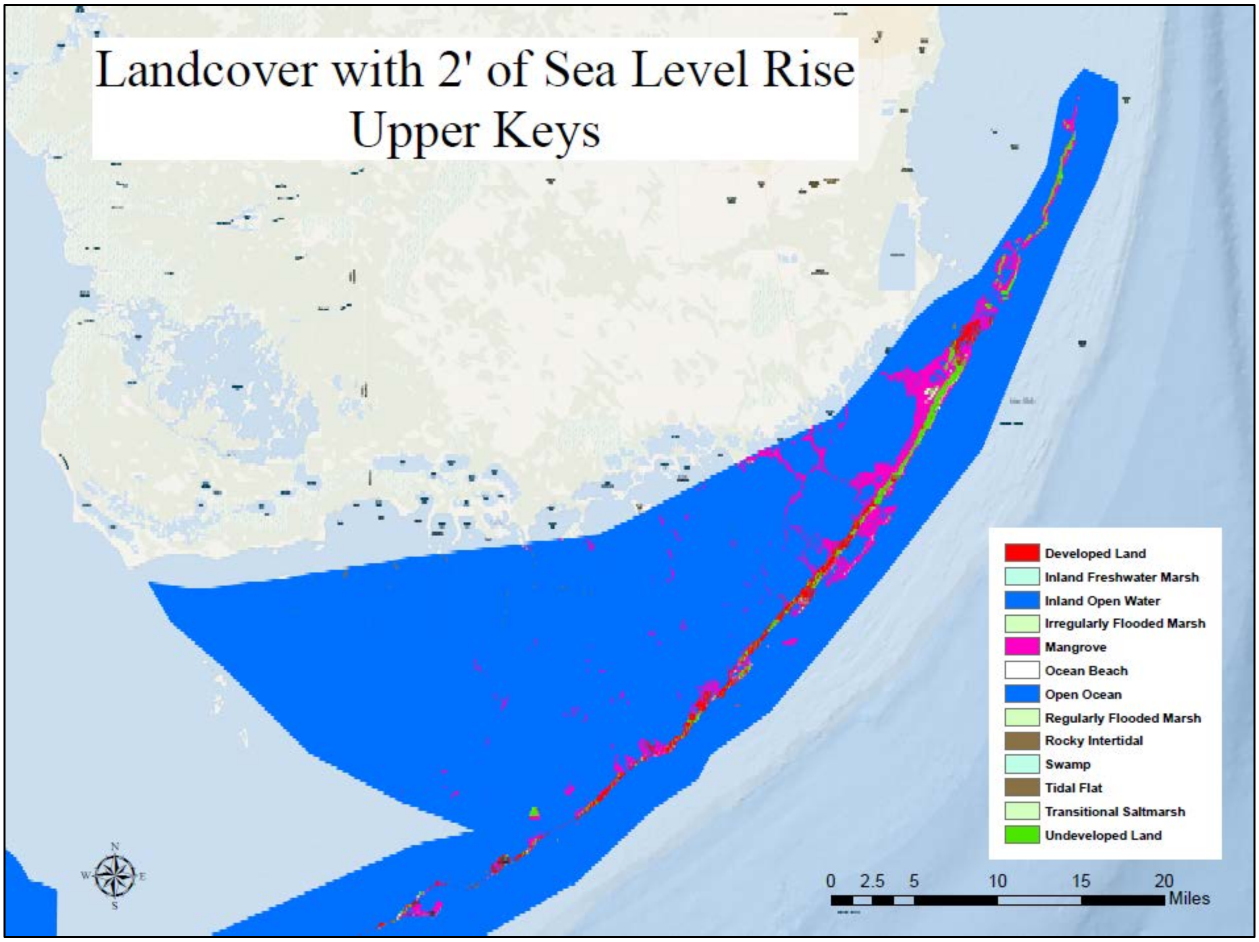
Landcover with 2' of Sea Level Rise
Upper Keys
Developed Land
Inland Freshwater Marsh
Inland Open Water
Irregularly Flooded Marsh
Mangrove
Ocean Beach
Open Ocean
Regularly Flooded Marsh
Rocky Intertidal
Swamp
Tidal Flat
Transitional Saltmarsh
Undeveloped Land
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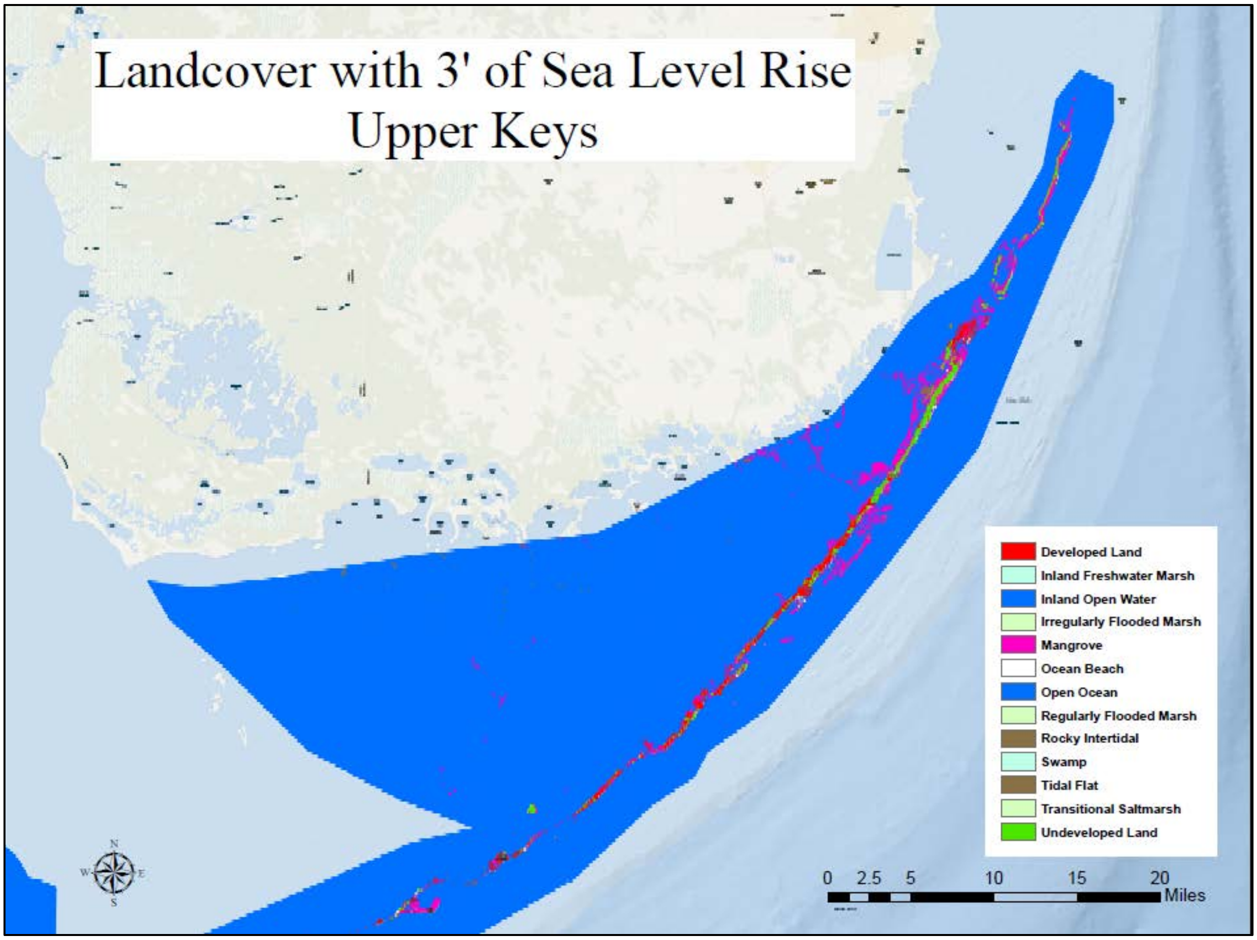
Landcover with 3' of Sea Level Rise
Upper Keys
Developed Land
Inland Freshwater Marsh
Inland Open Water
Irregularly Flooded Marsh
Mangrove
Ocean Beach
Open Ocean
Regularly Flooded Marsh
Rocky Intertidal
Swamp
Tidal Flat
Transitional Saltmarsh
Undeveloped Land
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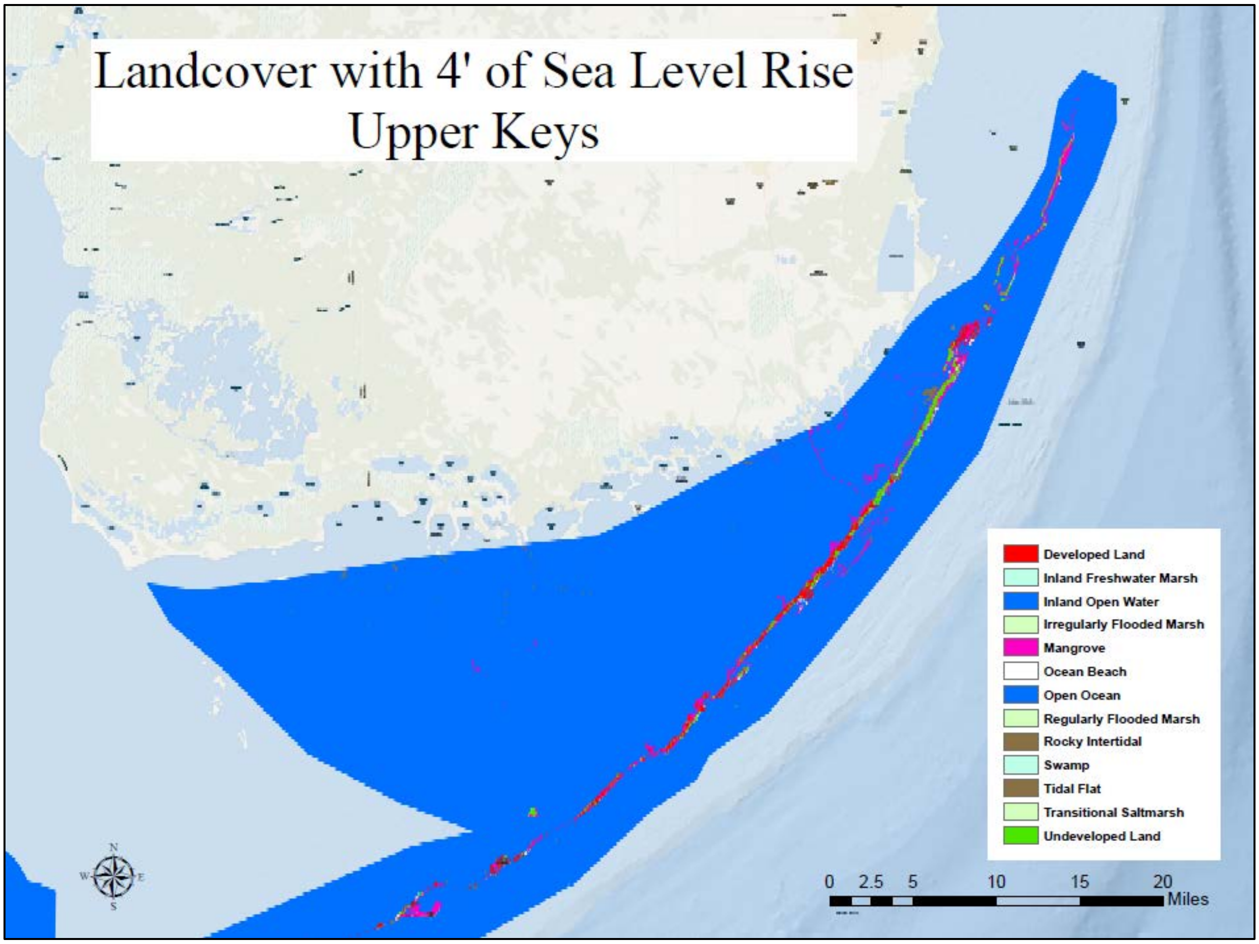
Landcover with 4' of Sea Level Rise
Upper Keys
Developed Land
Inland Freshwater Marsh
Inland Open Water
Irregularly Flooded Marsh
Mangrove
Ocean Beach
Open Ocean
Regularly Flooded Marsh
Rocky Intertidal
Swamp
Tidal Flat
Transitional Saltmarsh
Undeveloped Land
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APPENDIX 3. WORKSHOP AGENDAS

3.1 WORKSHOP 1 AGENDA

<u>Keys Terrestrial Climate Adaption Workshop 1</u>

'Addressing Impacts and Determining Adaptation Actions for Threatened and Endangered Species in the Florida Keys'

State of Florida Office Building, Marathon, Florida

February 28th & March 1st, 2017

<u>DRAFT AGENDA</u>

Workshop Leader: Logan Benedict

Sponsors: US Fish and Wildlife Service, Florida Fish & Wildlife Conversation Commission, & The Nature Conservancy

Workshop Goal:

1. Using scenarios and other best available science, develop climate change adaptation strategies and actions for the terrestrial federally threatened and endangered species throughout the Florida Keys for agencies and other conservation interests to consider in their immediate and long-range planning efforts.

Workshop Objectives:

1. Determine area specific species impacts
2. Generate area specific potential adaptation actions

Items to review prior to meeting:

1. Agenda
2. Webinar on validating species range maps
3. Definitions & background handout

<u>Tuesday February 28th, 2017</u>

Arrive in time to be ready to start at 12:30 PM

Time	Agenda Topic	Process	Desired results

12:30	Welcome and Opening Statements	• Bob give everyone a welcome
		• Welcome
		• Introductions
		• Overall Projects Goals
		  o Why the Keys?
		  o Timeline
		  o Expected outcomes
		• Workshop Goals & Objectives
		  o Expectations of participants, including outputs or products from this workshop
		• Meeting format and agenda review
		• Ground rules
			Participants have been introduced and understand the meeting purpose and objectives. Participants have been informed about the overarching goals of the project.

1:00	Current State of Knowledge – Chris & Jason	• Present participants with climate research background in the Keys
		  o Science behind it
		  o Known/observed changes
		  o Perhaps add relatable examples of island impacted by SLR (Bramble Kay)
			Participants up to speed on current information for climate change research in the Keys, and its future implications

1:20	What Changes Are You Seeing?	• Outline impacts of climate change in specific areas of the keys (already observed) o Can be related to habitat, species, or both	Participants contribute their perspectives and experiences about changes on the landscape.
2:10	Climate Change Thresholds	• Review sea level rise conditions • Present SLAMM maps • Present species distribution maps	Participants knowledgeable on the sea level rise thresholds, and supportive materials that will be used for exercises
2:40	Break		

Time	Agenda Topic	Process	Desired results
2:50	Breakout Groups: Brainstorming Impacts to T&E Species & their habitats (2 groups)	Participants have relevant current information on species and distributions Maps & projections made available o Current distributions o Future projections Sea level rise context made available Participants will: • Determine impacts spatially • Determine Impacts at each SLR interval	Participants have outlined expected impacts to T&E species and habitats. Participants have outlined what impacts are expected to occur at each interval of SLR, and where they are expected to occur.
4:30	Exercise Report out	• Participants briefly share their current results • Questions	Groups have shared their results and any questions have been answered
4:40	Wrap up and Day 2 preview	• Overview of day one • Preview day two • Housekeeping • Dinner plans	Any issues clarified, and participants prepped for following day.
5:00	Adjourn		

Wednesday March 1st, 2017

Time	Agenda Topic	Process	Desired results
8:30	Opening remarks and day 2 framework	• Welcome Back • Quick recap of day one • Day two objectives	Previous day reviewed. Participants are informed on activities for day two.
8:40	Breakout Groups: Brainstorming Impacts to T&E Species & their habitats (same 2 groups)	Resume exercise from previous evening Participants have relevant current information on species and distributions Maps & projections made available o Current distributions o Future projections Sea level rise context made available Participants will: • Determine impacts spatially • Determine Impacts at each SLR interval	Participants have reviewed their impact outputs and have added any additional thoughts
9:20	Exercise Report Out	• Participants briefly share any changes or additions to their results from the day before • Questions	Groups have shared their results and any questions have been answered
9:30	Break Out Groups: Brainstorming Adaptation Actions	• Participants generate adaptation actions for each species, given the impacts outlined the day before. May continue to do this via habitat. o Determine priority areas based on impacts from previous day. o Give site specific answers (I.e. Move species located in area X to area Y, build resilience to key identified habitat in area Z) o Have actions for differing levels of sea level rise	Participants have generated adaptation actions for all T&E species, to account for all expected impacts at each sea level rise interval.

Time	Agenda Topic	Process	Desired results
10:40	Break		
10:50	Break Out Groups: Brainstorming Adaptation Actions (Continued)	• Groups come back together and resume 9:30 exercise.	Participants have reviewed their actions, and have added any additional thoughts
11:40	Exercise Report Out	• Participants briefly share results • Questions	Groups have shared their results and any questions have been answered
11:50	Wrap up & break for lunch		All participants back by 12:50 and ready to start by 1:00 pm
1:00	Break Out Groups: Brainstorming Trigger Points	• Groups determine when the need to execute adaptation actions would be reached o At what population # do you execute plan Y o At what point (population #, sea level, percent habitat loss, etc.) do you switch to ex-situ actions o When do you stop management actions in area X?	Trigger points outlined for all T&E species. Participants agree on what trigger points will be.
2:00	Break		
2:10	Break Out Groups: Brainstorming Trigger Points	• Groups come back together and resume 1:00 exercise.	Participants have reviewed their trigger points, and have added any additional thoughts
3:00	Exercise Report Out	• Groups share their results • Questions	Groups have shared their results and any questions have been answered
3:10	Wrap up and Feedback	• Overview of workshop • Next steps • Next workshop time and focus	Decisions clarified, and participants informed about next steps. Workshop +/deltas captured

Time	Agenda Topic	Process	Desired results
		• Feedback • Q&A	
3:30	Adjourn		

3.2 WORKSHOP 2 AGENDA

Keys Terrestrial Climate Adaption Workshop 2

'Moving Forward with Adaptation for Threatened and Endangered Species in the Florida Keys'

State of Florida Office Building, Marathon, Florida

April 5th & 6th, 2017

DRAFT AGENDA

Workshop Leader: Logan Benedict

Sponsors: US Fish and Wildlife Service, Florida Fish & Wildlife Conversation Commission, & The Nature Conservancy

Project Goal:

2. Using scenarios and other best available science, develop climate change adaptation strategies and actions for the terrestrial federally threatened and endangered species throughout the Florida Keys for agencies and other conservation interests to consider in their immediate and long-range planning efforts.

Workshop Objectives:

3. Determine area specific adaptation actions to push forward
4. Determine risks of area specific adaptation actions and inaction
5. Discuss the tools and adaptive capacity of each organization
6. Discuss opportunities for policy and planning

Items to review prior to meeting:

4. Agenda & Definitions
5. Pre-Workshop Worksheet
6. Workshop 1 results

Wednesday April 5th, 2017

Arrive in time to be ready to start at 12:30 PM

Time	Agenda Topic	Process	Desired results
12:30	Welcome and Opening Statements	• Bob give everyone a welcome • Welcome • Introductions • Overall Projects Goals o Why the Keys? o Timeline o Expected outcomes • Workshop Goals & Objectives o Expectations of participants, including outputs or products from this workshop • Meeting format and agenda review • Ground rules	Participants have been introduced and understand the meeting purpose and objectives. Participants have been informed about the overarching goals of the project.
1:00	Climate Smart Conservation	• Present participants with climate smart conservation cycle, and how it applies to this project	Participants up to speed on climate smart cycle and what part they will be exercising.
1:20	Climate Change Thresholds & WS1 results	• Review SLAMM maps • Present species distribution maps • Present consequences, actions, trigger points, & monitoring needs.	Participants knowledgeable on the sea level rise thresholds, and supportive materials that will be used for exercises
1:50	Breakout Groups: Determining priority actions for T&E Species & their habitats (2 groups)	Participants have relevant current information on species and distributions Maps & projections made available o Current distributions o Future projections o Species expert results (workshop 1) Participants will: • Determine what actions can be implemented now o What new actions can you take o What are you doing already that needs small adjustments?	Participants have determined which actions need to be taken for T&E species and habitats.

Time	Agenda Topic	Process	Desired results
2:50	Break		
3:05	Breakout Groups: Determining priority actions for T&E Species & their habitats (2 groups	• Resume 1:50 exercise	Participants have determined which actions need to be taken for T&E species and habitats.
4:20	Exercise Report out	• Participants briefly share their current results • Questions	Groups have shared their results and any questions have been answered
4:40	Wrap up and Day 2 preview	• Overview of day one • Preview day two • Housekeeping • Dinner plans	Any issues clarified, and participants prepped for following day.
5:00	Adjourn		

Thursday April 6th, 2017

Time	Agenda Topic	Process	Desired results
8:30	Opening remarks and day 2 framework	• Welcome Back • Quick recap of day one • Day two objectives	Previous day reviewed. Participants are informed on activities for day two.
8:35	Break Out Groups: Assessing Risk	• Determine risks & costs of adaptation actions or inaction • Discuss how to avoid maladaptation	Participants understand risks of action and inaction
10:20	Exercise Report Out	• Participants briefly share results • Questions	Groups have shared their results and any questions have been answered
10:40	Break		
10:50	Full Group: Adaptive Capacity	• Group discusses adaptive capacity of agencies, region, and public • Group discusses future of adaptation in the Keys	Participants have discussed roadblocks to adaptation and future steps
11:50	Lunch Break		
1:00	Full Group: Agency Policy & Planning	• Group discusses changes needed in agencies and local governments • Building climate change into planning	Participants have discussed larger scale changes necessary for future success
2:30	Wrap up and Feedback	• Overview of workshop • Next steps • Next workshop time and focus • Feedback • Q&A	Decisions clarified, and participants informed about next steps. Workshop +/deltas captured
3:00	Adjourn		

3.3 WORKSHOP 3 AGENDA

Keys Terrestrial Climate Adaption Workshop 3

‘What Prevents us from Implementing Climate Adaptation Actions’?

Hyatt Place Orlando Airport
5435 Forbes Pl, Orlando, FL 32812
June 12th and 13th , 2018

WORKSHOP AGENDA

Workshop Goal: To determine barriers to implementing climate adaptation actions, and how to overcome them

DAY 1 – June 12th
Arrive in time to be ready to start at 12:30 PM

Start Time	Agenda Topic	Process
12:30	**Welcome and Opening Statements**	• Welcome & Introductions • Review meeting format, agenda, meeting goal, objectives, & ground rules
12:50	**A brief perspective on previous work**	• Bruce Stein–*National Wildlife Federation:* Climate Smart Conservation • Bob Glazer & Logan Benedict–*Florida Fish and Wildlife*: FWC’s Climate Change work, & The Florida Keys
1:10	**MeetingSphere**	• Beth Stys–*Florida Fish and Wildlife:* Introduction to MeetingSphere • Connect participants
1:20	**How do we manage for change?**	• Gregor Schuurman – *National Park Service:* Climate Adaptation Success Stories and Decisions • Full participant group case study on managing for change: Pine rocklands habitat
2:40	**BREAK**	
2:55	**Plenary Session: Implementing Climate Adaptation Actions & Barriers**	• Susan Clayton – *The College of Wooster*: Psychological barriers to engaging with climate change • Alejandro Camacho – *University of California Irvine*: Legal Barriers to Climate Adaptation • Nancy Gassman – *City of Fort Lauderdale*: Buying into a Different Future • Cara Pike – *Climate Access*: Climate Change Communication
3:35	**Determining roadblocks and how to navigate them -Stage 1**	• Break into teams & review case study species information • Define managing for change for case study species • Determines barriers to implementing actions and categorize them • Molly Cross – *Wildlife Conservation Society*: Overcoming barriers
4:50	**Wrap up and Day 2 preview**	

Start Time	Agenda Topic	Process
5:00	ADJOURN	

DAY 2 – June 13th

Time	Agenda Topic	Process
8:30	**Welcome and Opening Statements**	• Welcome • Outline Day 2 objectives
8:45	**Determining roadblocks and how to navigate them - Stage 2**	• Break out into teams from previous afternoon and review and revise list of barriers to implementing actions if necessary, and places them in the appropriate category • Determines steps to overcome or eliminate barriers • Determines needed parties for navigating each barrier
10:30	**BREAK**	
10:45	**Reviewing our results**	• Groups come back together and share their results • Open discussion on each case study • Discussion on the exercise process
12:00	**LUNCH BREAK -** In house working lunch	
1:00	**A wider perspective**	• Group discussion on how the case studies fit into the larger realm of climate adaptation planning and implementation
2:30	**Wrap up and products**	• Review of meeting products • Explain how information generated here will be utilized • Additional business as needed • Thank you
3:00	**ADJOURN**	

APPENDIX 4. WORKSHOP FEEDBACK

This appendix contains the combined feedback from workshops 1 & 2.

Participant Feedback
• SLAMM maps are needed for the Tortugas and the Marquesas • There are several other species that could be considered in this style of planning • We should look at planning for habitat types instead of single species • The public and local governments should be involved in planning • A short report is needed for each species • The final product needs to be communicated to policy makers and public • SLAMM needs a way to differentiate upland habitats to help divide tropical hammock, cactus hammock, pine rockland, etc.

APPENDIX 5. PRE WORKSHOP 2 WORKSHEET

This worksheet was generated for participants to review before Workshop 2 to get them thinking about needed changes to current management.

NAME	AGENCY/ORG

Federally Listed Species Management Matrix

Make a check mark under Active Management if you or your agency/org actively manage the species in the adjacent column. Then check under each interval of sea level rise if your current management is likely viable under those conditions (given impacts from handout)

	Active Management	Mgmt. at 1ft	at 2ft	at 3ft	at 4ft
Birds					
Roseate Tern					
Reptiles					
American Crocodile					
Indigo Snake					
Mammals					
Key Deer					
Key Largo Cotton Mouse					
Key Largo Woodrat					
Lower Keys Marsh Rabbit					
Rice Rat					
Invertebrates					
Miami Blue Butterfly					
Schaus Swallowtail					
Florida Leafwing					
Bartram's Hairstreak					
Stock Island Tree Snail					
Plants					
Semaphore Cactus					
Big Pine Partridge Pea					
Keys Tree Cactus					
Cape Sable Thoroughwort					
Blodgett's Silverbush					
Garber's Spurge					
Sand Flax					
wedge Spurge					

Species Management Objectives

Current management objectives for the species you checked above. Please denote if any management objectives currently account for climate change.

1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16

Suggested Changes to Management Objectives

Here we assume habitat protection (e.g. land purchases) and management (e.g. invasive species control and fire management) are a given, we are looking for adjustments to management such as; increased nesting habitat, increased population, increased genetic diversity, increased area of occupied habitat, increased number of subpopulations to spread risk, etc.

1
2
3
4
5

6	-	-	-	-	-
7	-	-	-	-	-
8					
9					
10					
11					
12					
13					
14					
15					
16					

APPENDIX 6. SPECIES-SPECIFIC RESULTS

Below, results from Workshops 1 and 2 are presented for each species. Each species has its federal listing status, species and habitat descriptions, and distribution map with participant comments. Each species will also have a table with broken up into lists of potential consequences from sea level rise, proposed adaptation actions, identified monitoring and trigger points, and top priority adaptation actions.

6.1 BIG PINE PARTRIDGE PEA

(*Chamaecrista lineata var. keyensis)*

Federal Status: Endangered

Description: The Big Pine partridge pea is a small perennial, herbaceous shrub that is 10-80 centimeters (cm) tall, with yellow flowers and pinnately compound leaves. The seed is an elongate pod, like that of a pea. This species is considered a distinct taxon, endemic to the lower Keys in Monroe County, Florida. It occurs naturally within pine rocklands of the lower Florida Keys, but also occupies adjacent disturbed sites, such as roadsides. Fire has important effects on survival of this species, by stimulating stem growth, fruiting, and seedling establishment.

Big Pine partridge pea. Photo by Hong Liu of Florida International University (FIU).

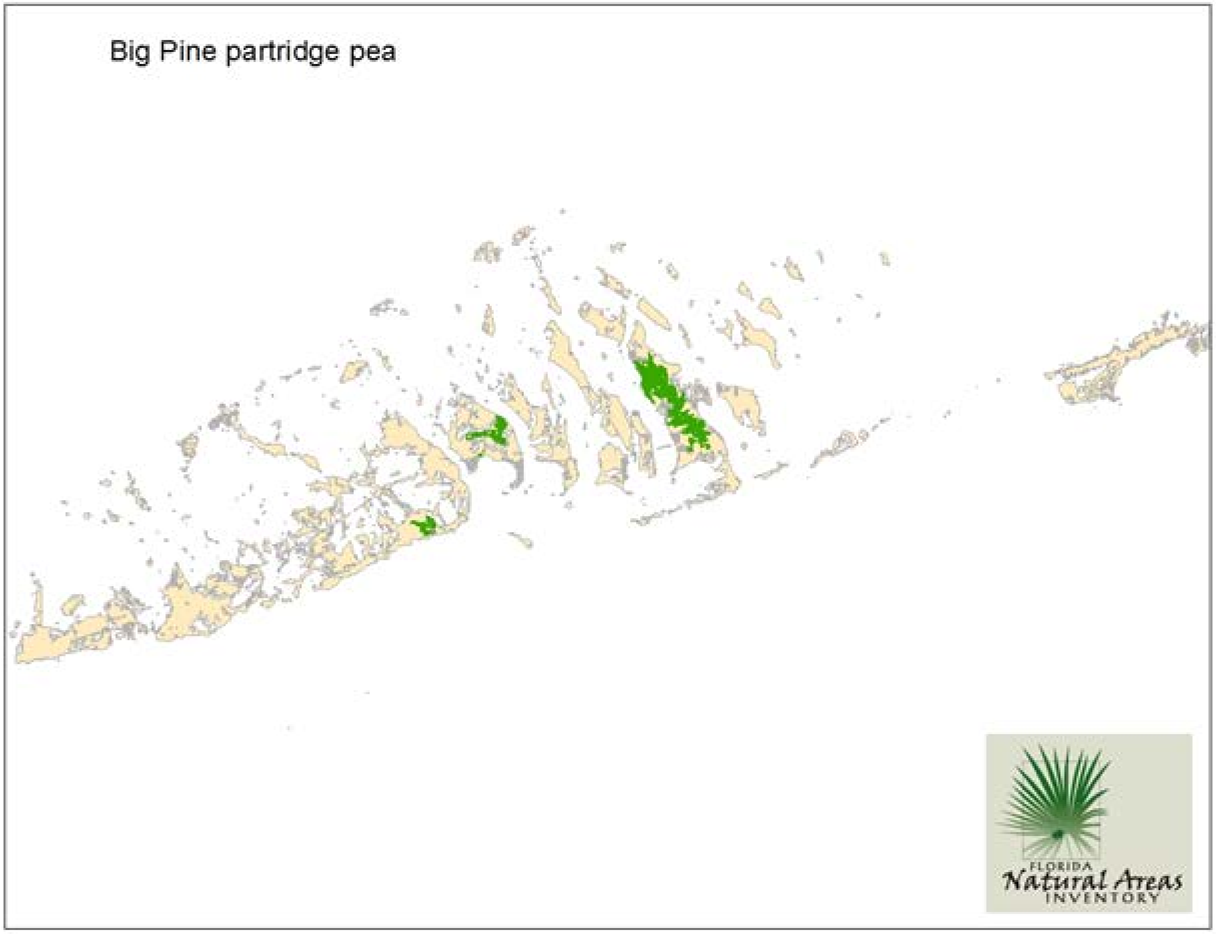


Figure 6.1. Known distribution of the Big Pine partridge pea. This map was produced by Florida Natural Areas Inventory.

Map Comments:

1) Big Pine Partridge Pea (*Chamaecrista lineata var. keyensis*): Cudjoe and Lower Sugarloaf Key populations are extremely small and occupy very little area. Living ex situ collection at Fairchild Tropical Botanical Gardens (FTBG). Many seeds stored at FTBG and National Laboratory for Genetic Resource Preservation (NLGRP).

Table 6.1. Big Pine partridge pea results. The contents of this table represent the information generated during workshop exercises. The contents of the first three rows are the recommendations of participants of Workshop 1, while the contents of row 4 are the priority actions determined by participants of Workshop 2.

Consequences of Sea Level Rise	● Big Pine Key population ○ 1 ft. 10% of population gone ○ 2 ft. 50% gone ○ 3 ft. 75% gone ○ 4 ft. 90% gone ● Lower Sugarloaf Key and Cudjoe Key ○ Both populations are already considered lost
Proposed Adaptation Actions	● On Cudjoe and Sugarloaf Key: No proposed augmentation because habitat is no longer suitable (dead pines after Wilma) ● Big Pine Key: Improve existing habitat using prescribed fire ● No Name Key: Recommend exploring habitat manipulation through mechanical disturbance and fire. After habitat manipulations, reintroduce new populations within its historical range. ● Little Pine Key: Possibly can execute same actions as on No Name Key.
Trigger Points and Monitoring	● Refine projections of habitat availability spatially (maps). Provide feedback from field observations on habitat shifts over short periods to improve model projections. ● Study C. lineata species complex taxonomy ● Research on potential recipient community impact (mainland) should be done now, so species might be introduced to mainland (or additional sites) ● Trigger Point: At 50% reduction (2ft & depending on a positive result of previous recipient site study) ● Trigger Point: Improve habitat on No Name Key & Little Pine Key once deemed appropriate habitat by criteria study (Reintroduce populations now)
Priority Actions	Now ● Study potential impact of translocation ● Build resiliency through fire now

	• Survey on No Name Key and Little Pine Key for reintroduction possibility, and potential for active fire management • Continue seed storage • Nursery propagation for planting on higher elevation lands Trigger at 2 feet • Increase intensity of fire and other habitat treatments • Begin translocation if studies determine this action is viable

6.2 BLODGETT'S SILVERBUSH

(Argythamnia blodgettii)

Federal Status: Endangered

Description: Blodgett's silverbush is a perennial shrub or herb, 10 to 60 cm tall, with a woody base and small green flowers. It is considered a southern Florida endemic, occurring only in Miami-Dade County and Monroe County throughout the Florida Keys. This species grows in pine rocklands, exposed areas of rockland hammock and coastal berm, and on roadsides. It grows in crevices of oolitic limestone or on sand. It occurs within pine rocklands, where it requires periodic fire to maintain an open, sunny understory. This species is known to tolerate some human disturbance, and can often be found along the disturbed edges of its historic habitats.

Blodgett's silverbush. Photo by James Lange of FTBG.

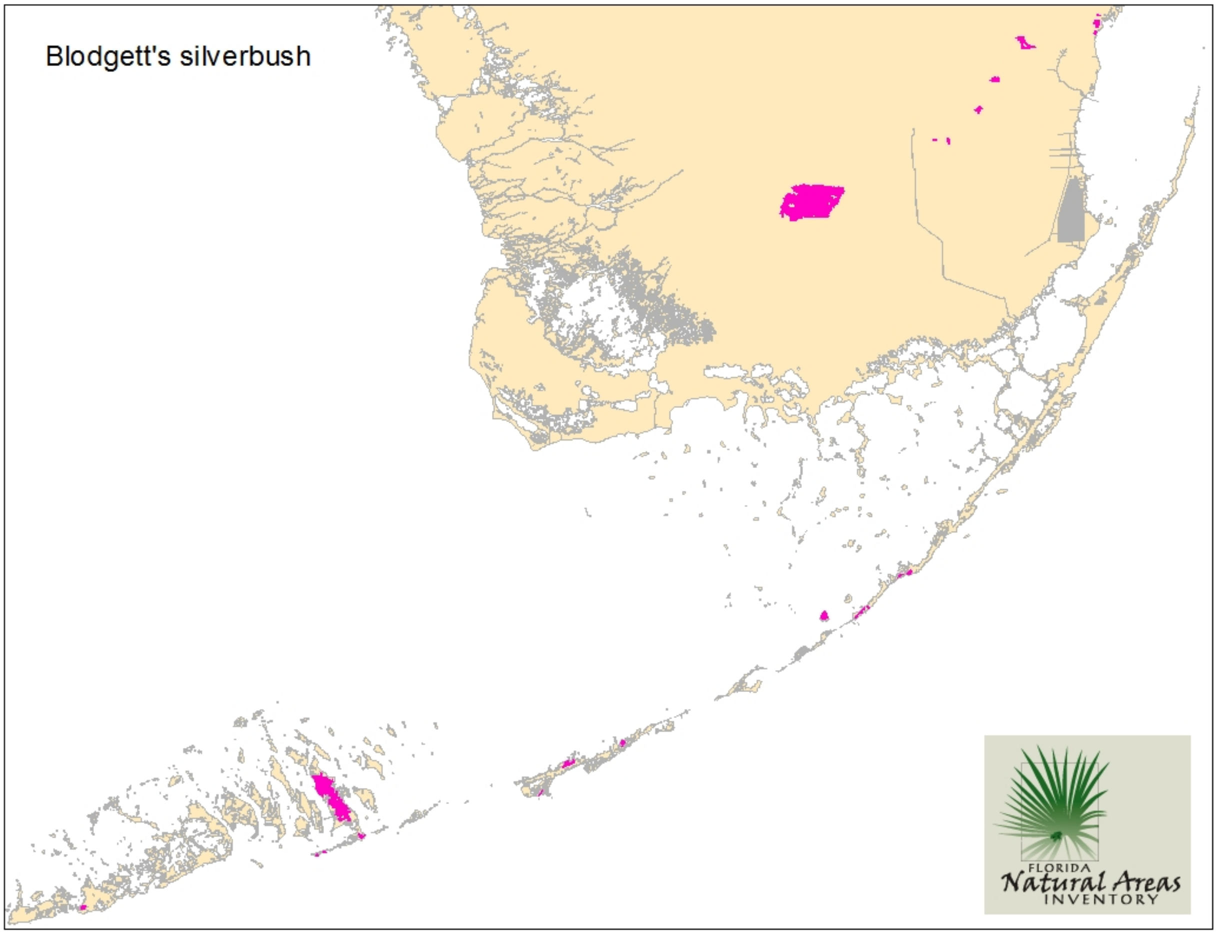


Figure 6.2. Known distribution of Blodgett's silverbush. This map was produced by Florida Natural Areas Inventory.

Map Comments:

1) It was hard to distinguish on the map if the range of this species was captured. In State Parks, it occurs on Long Key, Windley Key and the Klopp tract located on lower Matecumbe Key.
2) Blodgett's Silverbush (*Argythamnia blodgettii*)- I think the population on rocklands of Big Pine is highly overrepresented. Most plants are in and around Cactus Hammock. I'd consider it very rare in rocklands north of there. There is also a small population in North Key Largo on FPL land adjacent to Dagny Johnson. Small living collection at FTBG. Small seed collection at NLGRP.

Table 6.2. Blodgett's silverbush results. The contents of this table represent the information generated during workshop exercises. The contents of the first three rows are the recommendations of participants of Workshop 1, while the contents of row 4 are the priority actions determined by participants of Workshop 2.

Consequences of Sea Level Rise	• Big Pine Key population
	    o Small amount left on Big Pine Key
	• Key Largo
	    o Added population (not currently on map)
	• All populations
	    o 1 ft. still ok
	    o 2 ft. habitat reduced
	    o 3 ft. Cactus hammock, Boca Chica gone. Potential for habitat on Marathon still
	    o 4 ft. Ligman Vitae, Key Largo habitat, and Windly habitat persists. Marathon population gone

Proposed Adaptation Actions	• Boca Chica: Seed collection will be difficult, once every 2-3 months collect all seeds available. This will still leave plenty of seed within the habitat. • Big Pine Key: Seed collection of 50% during each visit (trips every 2-3 moths). One year collecting cycle, and then reevaluate. • No augmentation needed on the Keys at this moment • Seeds would be collected for ex-situ seed banking, future augmentations (as needed), and reintroduction into historic ranges
Trigger Points and Monitoring	• Research needed on salt tolerance, dispersal, pollinators, seed storage/germination (viability), and genetics to make decisions on intensity or need of collection/translocation • Research is not high priority for this species for population genetics • Research the impact of relocation. • Trigger Point: Relocate to mainland at 50% loss, pending research outcomes.
Priority Actions	Now • Seed collection by Fairchild Botanical Garden Future actions: • At 50% population reduction, relocate to mainland • Seed storage • Research salt tolerance and genetic diversity • Habitat augmentation • Exotic removal and fire

6.3 CAPE SABLE THOROUGHWORT

(Chromolaena frustrata)

Federal Status: Endangered

Description: The Cape Sable thoroughwort is a small herbaceous plant with bluish-purple flowers. This plant exists within the Everglades National Park, and a few locations in the Florida Keys. The Cape Sable thoroughwort is associated with coastal rock barrens and berms, edges of rocklands hammocks, and pine rocklands. It is estimated that only 5 protected populations remain.

Cape Sable thoroughwort. Photo by James Johnson.

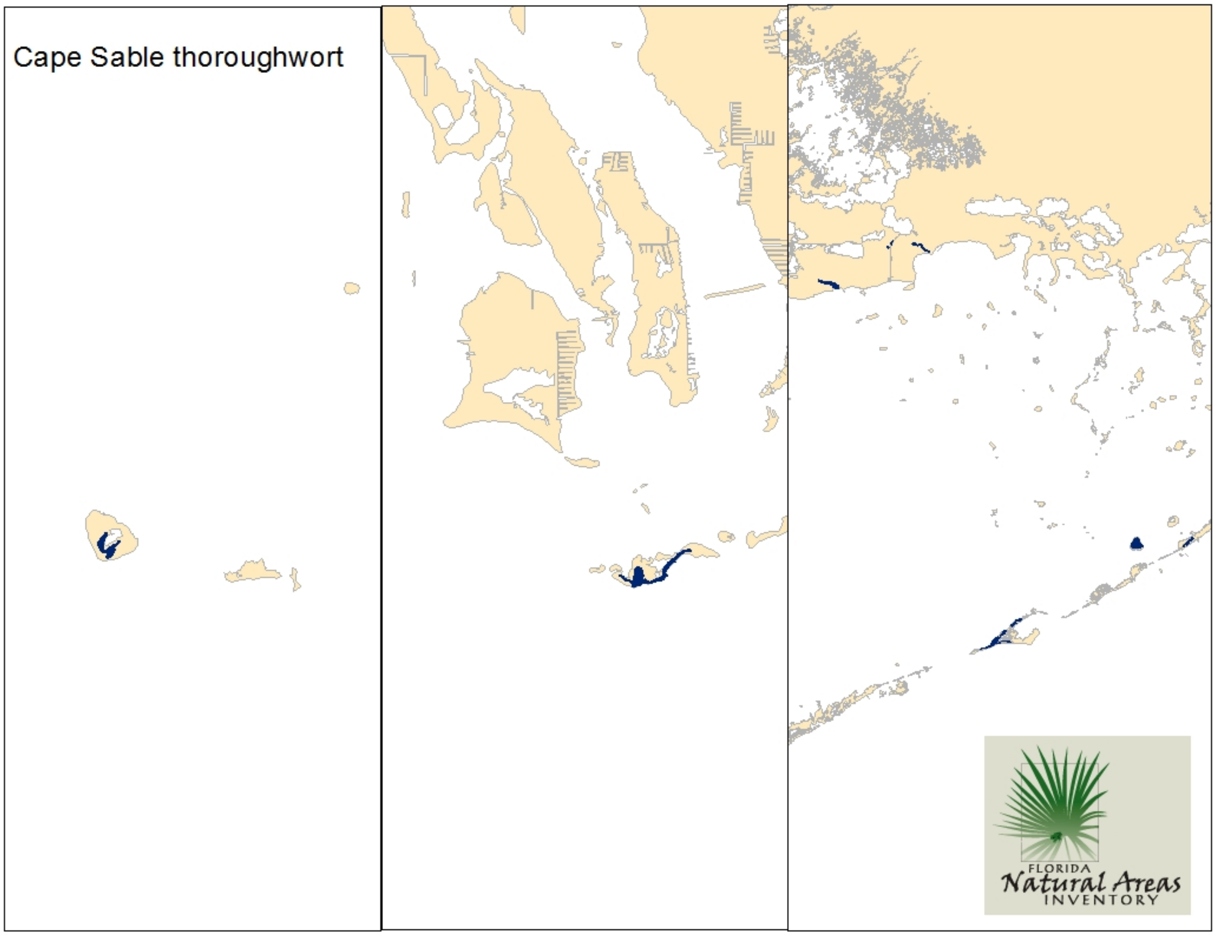


Figure 6.3. Known range of the Cape Sable thoroughwort. This map was produced by Florida Natural Areas Inventory.

Map Comments:

1) This species is also found on the Klopp tract on lower Matecumbe Key.
2) Cape Sable Thoroughwort (*Chromolaena frustrata*): Generally, Keys maps over represent (Big Munson island for example not on berm area, and Lignum Vitae Key only had 2 adult plants right next to each other when Janice Duquesnel and I surveyed last year) while ENP maps of Cape Sable region underrepresent (Thousands of plants when we surveyed in 2014, map of Cape Sable Hammock should extend further west). Large living collection of plants as well as seeds at FTBG. Many seeds at NLGRP.

Table 6.3. Cape Sable Thoroughwort results. The contents of this table represent the information generated during workshop exercises. The contents of the first three rows are the recommendations of participants of Workshop 1, while the contents of row 4 are the priority actions determined by participants of Workshop 2.

Consequences of Sea Level Rise	• Populations exist on Boca Grande, Big Munson, Long Key, Choate, and Lignumvitae o 1 ft. Boca Grande and Northern Long Key gone; Lignumvitae and Southern Long Key stressed, o 2 ft. Big Munson and Lignumvitae populations gone; Southern Long Key stressed but still ok o 3 ft. Southern Long Key population gone; Choate population stressed o 4 ft. Choate population gone
Proposed Adaptation Actions	• Need to establish ex situ collection and seed banking • Out plantings are needed, and assisted dispersal of seeds in priority areas
Trigger Points and Monitoring	• Research needed on salt tolerance, dispersal, pollinators, seed storage/germination (viability), and genetics to make decisions on intensity or need of collection/translocation • Research the impact of relocation now, and based on the outcome relocate to mainland at 50% loss • Focus on genetics of mainland population vs Keys population • Monitor populations annually
Priority Actions	Now • Determine priority areas for out plantings • Continue seed storage at Fairchild Botanical Gardens • Research needed on genetics of mainland vs Keys populations, dispersal, and nursery propagation • Propagation, reintroductions, and augmenting current populations Trigger Point between 2-3 feet • Switch to mainland efforts and transplants depending on results of studies

6.4 GARBER'S SPURGE

(Euphorbia garberi)

Federal Status: Endangered

Description: This ephemeral species is found in multiple habitat types, and can exist in sandy soils of pine rocklands, hammock edges, coastal rock barrens, grass prairies, salt flats, beach ridges, and swales. This species can also be adaptable to shifting habitats, and can be locally abundant. There are populations in the Florida Keys, and populations on mainland.

Garber's spurge. Photo by Jennifer Possley FTBG.

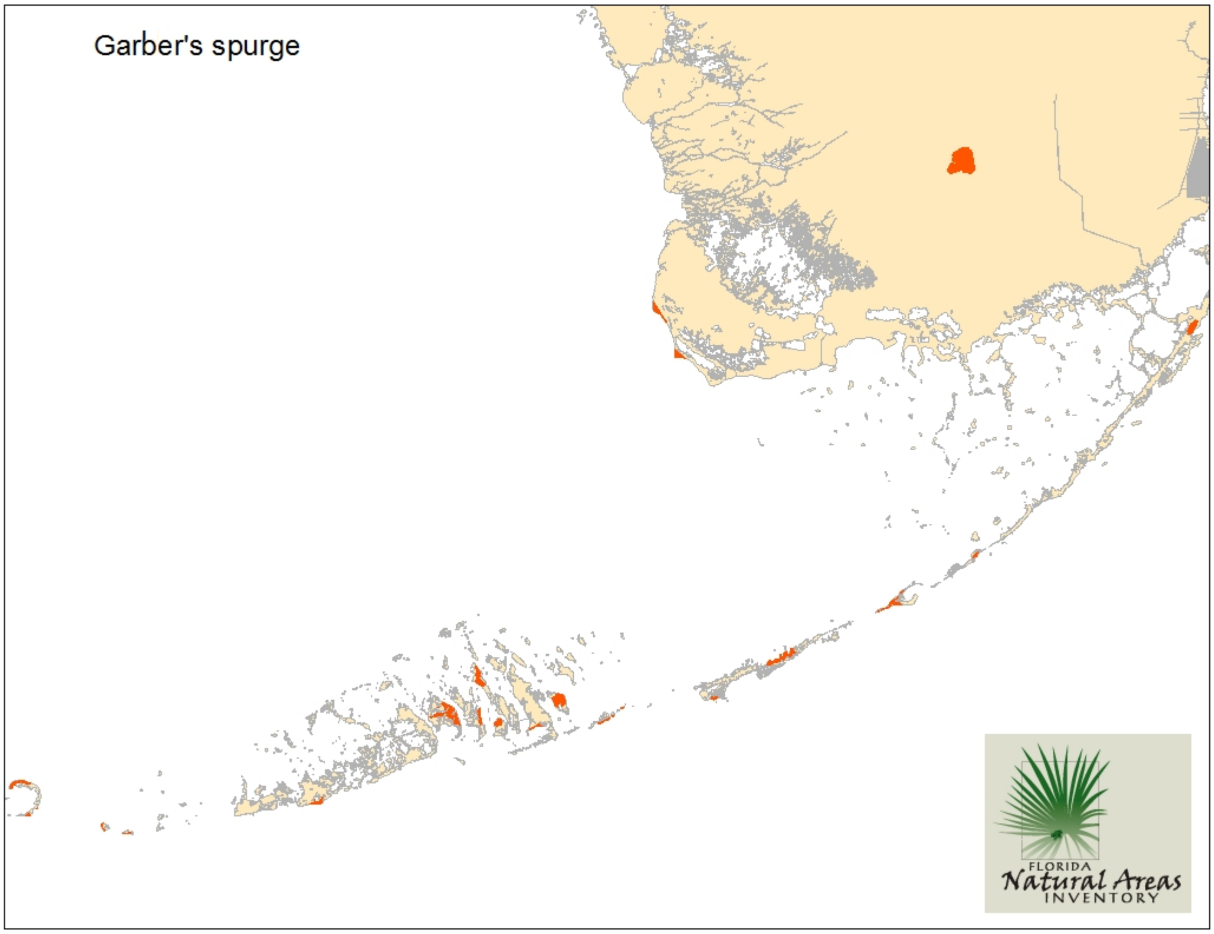


Figure 6.4. Known range of Garber's spurge. This map was produced by Florida Natural Areas Inventory.

Map Comments:
1) This species is also found at Bahia Honda State Park.
2) Garber Spurge (*Euphorbia garberi*) population in the Deering Estate in Miami-Dade County. A small population on Big Munson Island. We have a living ex situ collection at FTBG. Many seeds at NLGRP.

Table 6.4. Garber's spurge results. The contents of this table represent the information generated during workshop exercises. The contents of the first three rows are the recommendations of participants of Workshop 1, while the contents of row 4 are the priority actions determined by participants of Workshop 2.

Consequences of Sea Level Rise	• All Keys populations o 1 ft. Long key gone, Lower Matecumbe Key gone, Boca Chica gone o 2 ft. Big Munson Island gone o 3 ft. Cudjoe gone o 4 ft. Marathon population ok, Bahia Honda population ok, Northern Keys Population ok. Big Pine gone

Proposed Adaptation Actions	• Obtain counts from seeds already in storage (Colorado) to determine the available resources for reintroductions or transplanting • Research needed to find suitability of populations and seeds for reintroductions or transplanting (salt tolerance, genetics) • Continued to manage areas of occurrence • Believe this species has a strong ability to adapt on its own
Trigger Points and Monitoring	• Seed collection amount and location may change based on information from research • Salinity tolerance research results may change priority genetics to preserve • Genetic work to compare keys populations and mainland populations will determine whether translocation of Keys populations is necessary • Need for annual monitoring of populations to assess next steps • No trigger point between now and 4 feet. May not be as in danger as other project species.
Priority Actions	Now • Genetic work to compare Keys populations and mainland populations to evaluate risk of translocations • Collect seeds • Use overarching plant adaptation concepts

6.5 KEY TREE-CACTUS

(Pilosocereus robinii)

Federal Status: Endangered

Description: The Key tree-cactus is a large cactus with erect columnar stems reaching up to 10 m, that produces white flowers and purplish-red fruits. It is endemic to Monroe County in the Florida Keys, FL. This species is associated with tropical hardwood hammocks, and a thorn-scrub associated habitat sometimes referred to as cactus hammocks.

Keys tree cactus. Photo credit Department of Environmental Protection (DEP).

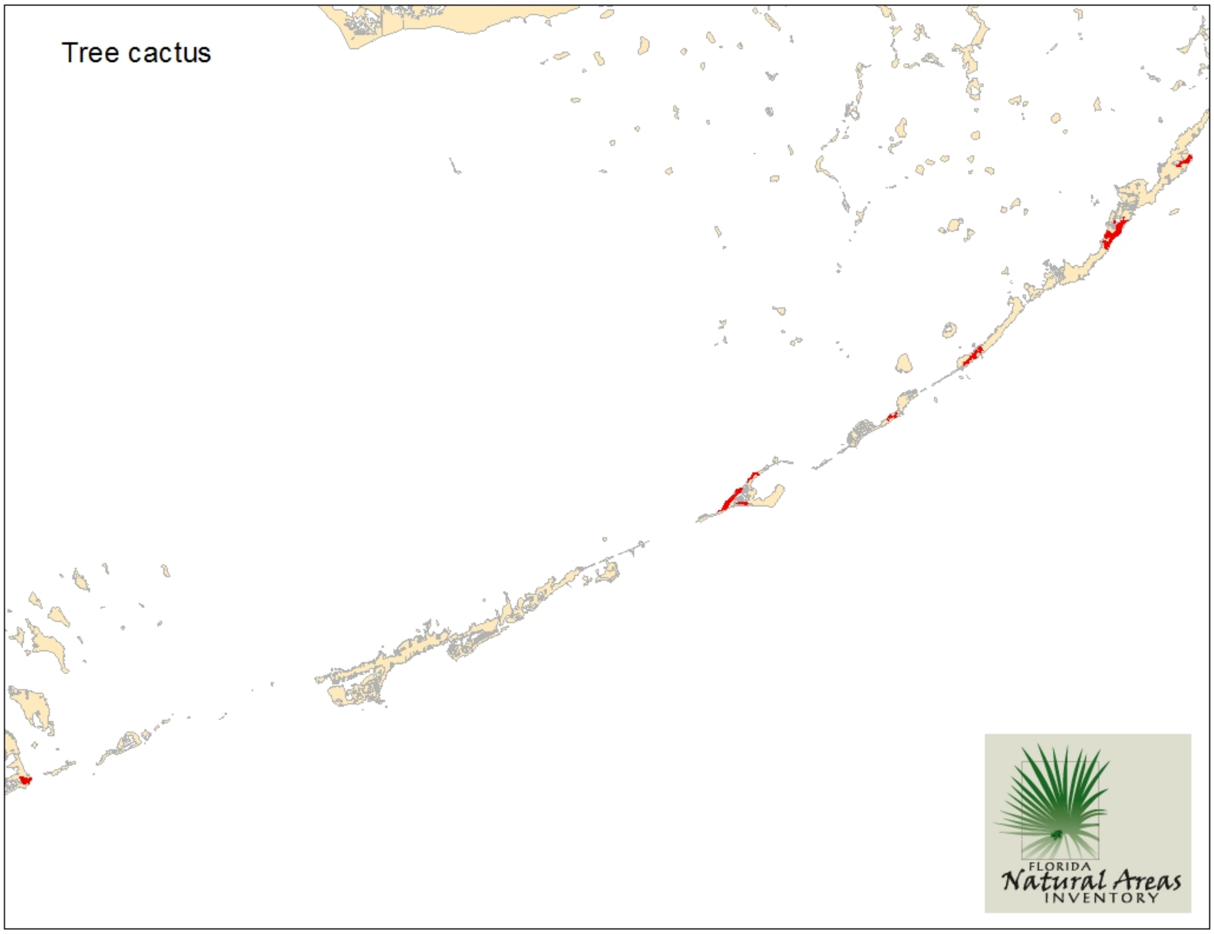


Figure 6.5. Known range of the Keys tree cactus. This map was produced by Florida Natural Areas Inventory.

Map Comments:

1) The Keys tree cactus has been reintroduced to Windley Key FRG State Park. We have three different outplanting locations, one of which is at the highest natural elevation in the Keys. We took into consideration the future projections for sea level rise and outplanted in habitats higher than where this species has historically occurred. There is a population of Keys tree cactus on land managed by Pennekamp State Park at MM 106. However, it is believed that this is a different species.
2) Tree Cactus (*Pilosocereus robinii*) – There is no extant population on Plantation Key. The population on private land just north of Layton on Long Key is extirpated. We rescued the last juvenile plant last year from a very disturbed habitat. There is a reintroduced population in Windley Key SP, with some individuals planted over 3m above sea level. There is another reintroduced population in Crocodile Lake NWR, with many individuals planted 2m above sea level. I should mention the natural population in Jon Pennekamp is thought to be (and I concur) another species (P. polygonus). Large ex situ collection of live plants at FTBG, along with many seeds at FTBG and NLGRP.

Table 6.5 Keys tree cactus results. The contents of this table represent the information generated during workshop exercises. The contents of the first three rows are the recommendations of participants of Workshop 1, while the contents of row 4 are the priority actions determined by participants of Workshop 2.

Consequences of Sea Level Rise	• 6 populations present in the wild (P. robinii), 1 population in Key Largo (P. polygonus) currently. o 1 ft. populations on Pennekamp will be affected (quality of plants affected negatively) as well as populations on Big Pine Key. Nuisance flooding events, salt water stress o 2 ft. Long Key pop on Golden Orb Trail affected, sea level rise will cause salt water laterally moving in, pushing vegetation back. Lower & upper Matecumbe stressed. Big Pine Key population highly stressed. o 3 ft. Big Pine Key will be extirpated. Long Key highly stressed, possibly extirpated. Some for lower/upper Matecumbe. o 4 ft. Big Pine Key extirpated, Long Key likely mortality, lower/upper Matecumbe likely extirpated.
Proposed Adaptation Actions	• Currently seed collection is under way. Continue these efforts • Suggest continual reintroduction at higher elevations • Augmentation of all existing populations already ongoing, suggested continuation • On Big Pine Key, collect germ plasm and introduce to Upper Big Pine Key
Trigger Points and Monitoring	• Population monitoring on a quarterly basis • Salinity tolerance testing complete, incorporate into decisions • Research needed on dispersal, pollinators, seed storage/germination (viability), and genetics to make decisions on intensity or need of collection/translocation • Research the impact of relocation now, and based on the outcome relocate to mainland at 50% loss
Priority Actions	Now • Continue outplanting and restoration efforts • Explore concept of planting on private lands • Monitor groundwater salinity and utilize tolerance data for trigger points Trigger • Consider ex-situ actions

6.6 SAND FLAX

(Linum arenicola)

Federal Status: Endangered

Description: Sand flax is a small, perennial herb that is 35 to 53 cm (14 to 21 in) tall with yellow flowers. When not in flower, it resembles a short, wiry grass. Its range consists of central and southern Miami-Dade County and Monroe County in the lower Florida Keys. It occurs in pine rocklands, disturbed pine rocklands, dry marl prairie, and disturbed areas on rocky soils. This species has been somewhat successful in human disturbed sites, such as roadsides adjacent to their historic habitats.

Sand flax. Photo by James Lange of FTBG.

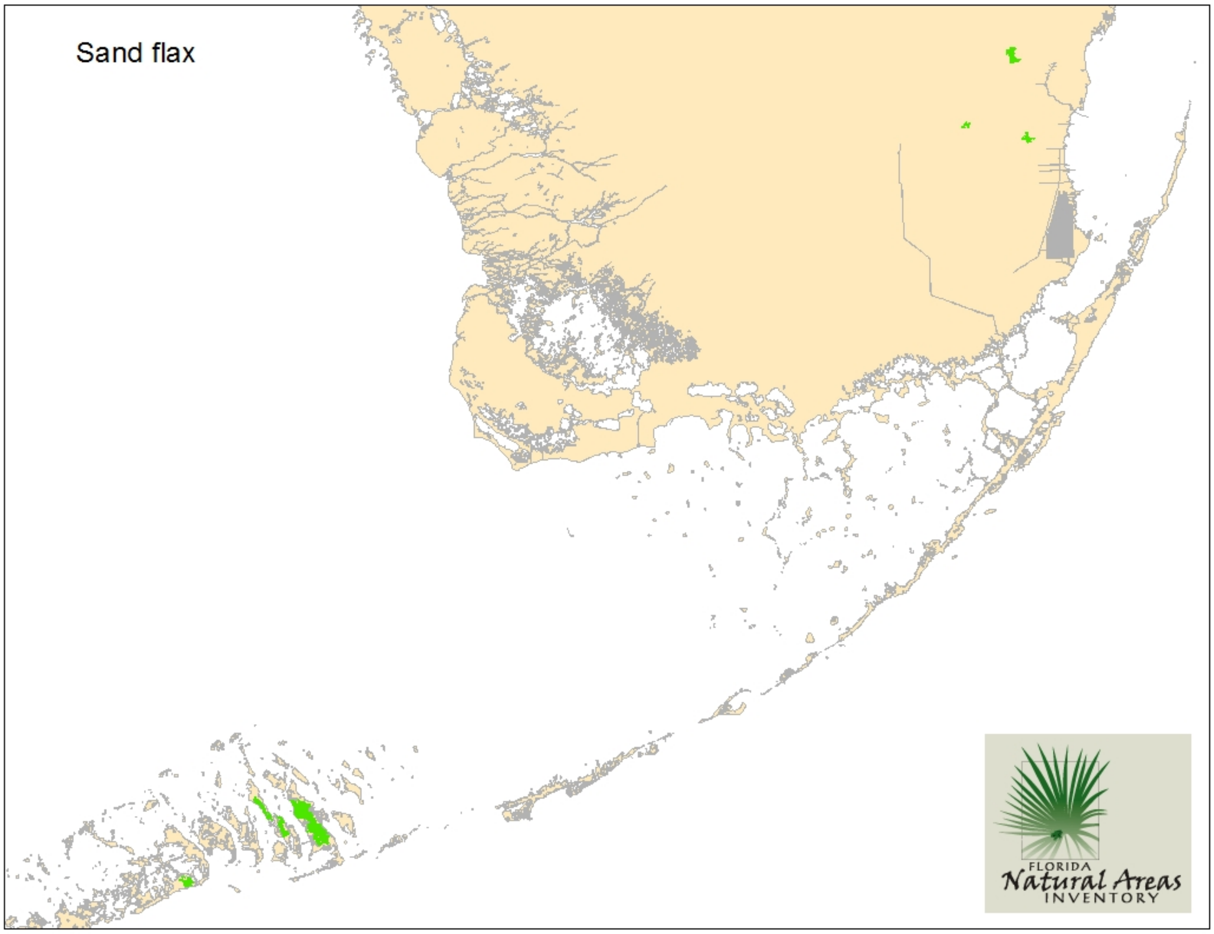


Figure 6.6. Known range of sand flax. This map was produced by Florida Natural Areas Inventory.

Map Comments:

1) Sand flax (*Linum arenicola*) a very large population (Est 10,000+) exists along the L31E levee. This certainly needs to be included before the meeting is over. Torch Keys and Lower Sugarloaf are in very narrow habitats along roadside. Large ex situ seed bank at NLGRP.

Table 6.6. Sand flax results. The contents of this table represent the information generated during workshop exercises. The contents of the first three rows are the recommendations of participants of Workshop 1, while the contents of row 4 are the priority actions determined by participants of Workshop 2.

Consequences of Sea Level Rise	• Current populations in Dade & Keys (Dade wasn't modeled)
	• Middle/little torch populations already gone.
	• Sugarloaf Key & Big Pine Key populations
	   o 1 ft. sugarloaf key extirpated. Big Pine Key ok
	   o 2 ft. Big Pine Key 50% gone
	   o 3 ft. Big Pine Key 90% gone
	   o 4 ft. Big Pine Key 95% gone

Proposed Adaptation Actions	• No action is a choice as this species is more adaptable than others • Ex situ (seed banking). Preserve at least what we can away from the sea level rise impacted areas • Augmentation of existing populations to increase resiliency • Managed relocations outside historic range • Manage for quality of the ecosystem • Test population genetics of different areas • Perform experiments on salt tolerance of different populations • Since Big Pine Key populations will persist longest within the Keys, and Sugarloaf will disappear first at 1 foot, action must in Sugarloaf must be priority. Sugarloaf key needs ex-situ conservation through seed collection. Need for salt water tolerance and genetics experiment prioritized here. • In Big Pine Key, continue augmentation of existing populations (robust) and management of the ecosystem
Trigger Points and Monitoring	• Research needed on salt tolerance, dispersal, pollinators, seed storage/germination (viability), and genetics to make decisions on intensity or need of collection/translocation • Research the impact of relocation now, and based on the outcome relocate to mainland at 50% loss • Annual monitoring needed • Propagation protocols need to be established • Demography study currently in progress (Craig Vanderheiden)
Priority Actions	Now • Propagation protocols needed alongside genetic work • Seed collection at Fairchild Botanical Gardens • Continue demography study Future Actions – Trigger point at 2 feet • Genetics work, salt tolerance, augment populations, increase fire • Survey Deering Airforce Base

6.7 SEMAPHORE CACTUS

(Opuntia corallicola)

Federal Status: Endangered

Description: The Semaphore cactus is a very spiny erect cactus with red flowers, that ranges from 3 to 15 feet tall. It is endemic to Monroe County in the Florida Keys, FL. This species historically occurs in the buttonwood zone between rockland hammock and coastal swamp. It is also historically known from coastal berms. This species no longer produces sexually, and functionally only males may remain.

Semaphore cactus. Photo by Janice Duquesnel

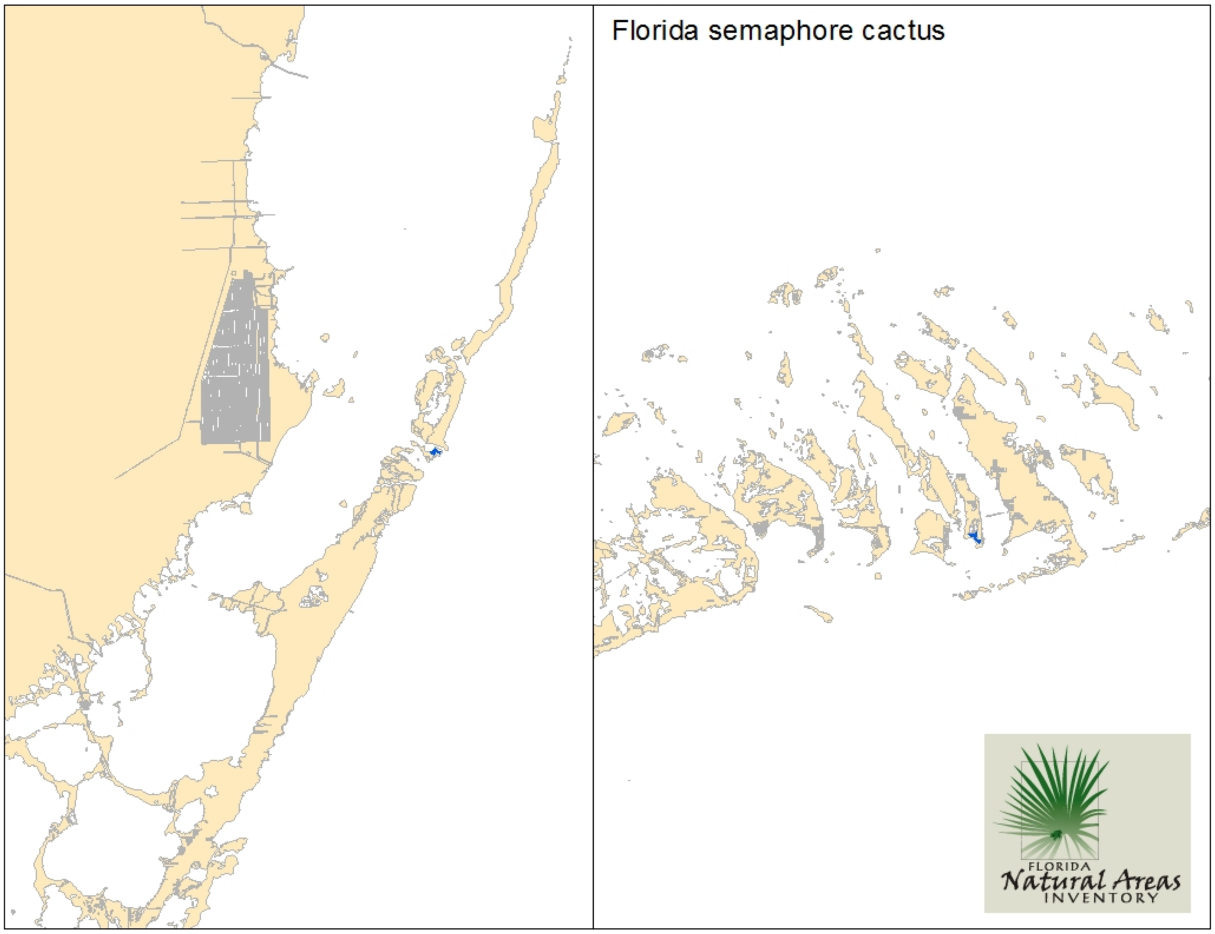


Figure 6.7 Known range of the Florida semaphore cactus. This map was produced by Florida Natural Areas Inventory.

Map Comments:

1) We reintroduced this species in 1996 in Dagny Johnson Key Largo Hammock Botanical State Park. The project has continued to add locations due to shift in habitat suitability. All of the coastal rock barren outplanting sites have had 100% mortality due to the extreme high tides in the fall. Several of the original outplanting sites are persisting, although one is only barely maintaining a population. I have increased abundance by outplanting individuals at higher elevations to compensate for loss of habitat. A natural population is located on Swan Key in Biscayne National Park. Other outplanting areas include FWC parcels.
2) Florida Semaphore Cactus (*Consolea corallicola*)- several introduced populations on Key Largo, as well as Dove Creek Hammocks, and Cactus Hammock on Big Pine (one large plant that I know of). Living ex situ collection at FTBG.

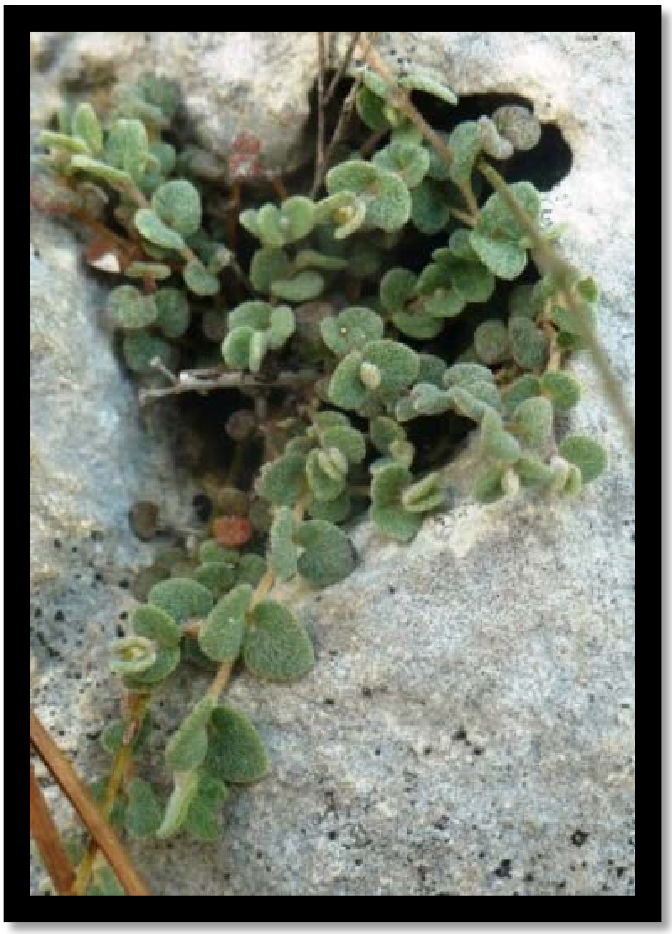
Table 6.7 Semaphore cactus results. The contents of this table represent the information generated during workshop exercises. The contents of the first three rows are the recommendations of participants of Workshop 1, while the contents of row 4 are the priority actions determined by participants of Workshop 2.

Consequences of Sea Level Rise	• Current wild populations: Swan Key; Big Pine Key introduced, Little Torch Key, Key Largo (Dove Creek falls off Map) o 1 ft. Coastal Rock & buttonwood ecotone impacted, Big pine Key stressed o 2 ft. Big Pine Key gone; Dove Creek impacted o 3 ft. o 4 ft. Swan Key population stressed. Reintroduced population not affected
Proposed Adaptation Actions	• Research needed on reproduction genetic work and pollination • Need to collect germ plasm • Out plantings are ongoing in all areas of higher elevations (hammock openings) and should continue in priority areas • Monitor shade thresholds & move to areas of higher sun when needed • Reintroduce to Big Pine Key at higher elevation areas
Trigger Points and Monitoring	• Population monitoring on a quarterly basis • Research needed on salt tolerance, dispersal, pollinators, seed storage/germination (viability), and genetics to make decisions on intensity or need of collection/translocation • Research the impact of relocation now, and based on the outcome relocate to mainland at 50% loss
Priority Actions	Now – Trigger may be now • Focus on reintroduced populations • Continue current efforts Future actions • Collect germ plasm • Research salt tolerance, viability, propagation needs • Continue reintroductions to build resilience • Functional reproduction • Evaluate introduction to private lands and developments as an ornamental

6.8 WEDGE SPURGE

(Chamaesyce deltoidea ssp. *Serpyllum)*

Federal Status: Endangered



Description: Wedge spurge is a small perennial herb with slender and numerous stem radiating out from a taproot. The leaves are 2 to 5 mm long, triangular, and covered with fine short fuzz, giving the plant a silvery appearance. This species is historically known from only Big Pine Key in the Florida Keys in Monroe County, Florida. It occurs in pine rocklands and adjacent disturbed sites on Big Pine Key, including roadsides. It can be found growing in crevices in oolitic limestone substrate, exposed rock substrate, open understories, and where hardwood and palm density is low. This species tends to be shade-intolerant and benefits from periodic burning to reduce competition from woody vegetation, and is found more frequently in recently burned areas.

Wedge spurge. Photo by Stephen Hodges.

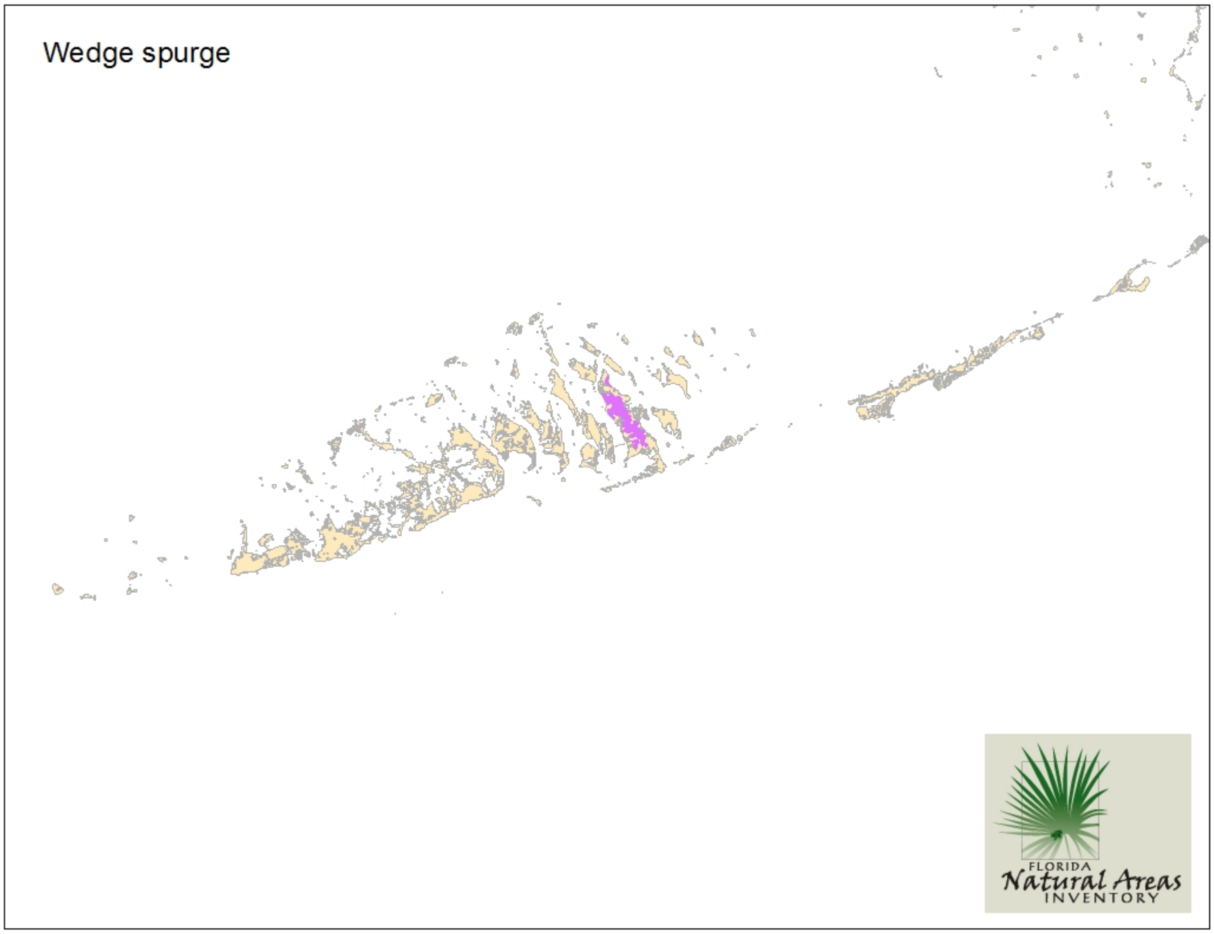


Figure 6.8. Known range of wedge spurge. This map was produced by Florida Natural Areas Inventory.

Map Comments:
None

Table 6.8. Wedge spurge results. The contents of this table represent the information generated during workshop exercises. The contents of the first three rows are the recommendations of participants of Workshop 1, while the contents of row 4 are the priority actions determined by participants of Workshop 2.

Consequences of Sea Level Rise	• Only existing population is on Big Pine Key o 1 ft. still ok o 2 ft. 20% gone o 3 ft. 30-40% gone o 4 ft. 80% gone
Proposed Adaptation Actions	All action suggested on Big Pine Key • More research on genetics is needed as well as how to better grow it in ex-situ conservation situations (nurseries, botanical gardens, etc.) • Need for ex-situ seed banking

	• Augmentation is needed of existing populations • Continue (robust) management of ecosystem, including use of fire • Mechanical disturbance is good as well (bulldozers, rakes, by hand) to create habitat
Trigger Points and Monitoring	• Research needed on salt tolerance, dispersal, pollinators, seed storage/germination (viability), and genetics to make decisions on intensity or need of collection/translocation • Research the impact of relocation now, and based on the outcome relocate to mainland at 50% loss • Trigger Point: Improve habitat on No Name Key and Little Pine Key and reintroduce now
Priority Actions	Now • Habitat management through prescribed fire and mechanical treatment • More seed collection is needed • Many actions can be aligned with Big Pine partridge pea Future – Trigger point between 1-2 feet • Research on salt tolerance, viability, genetic testing for unique genotypes, and further seed collection • Reintroduction on No Name Key and Little Pine Key, with management

6.9 BARTRAM'S SCRUB-HAIRSTREAK BUTTERFLY

(Strymon acis bartrami)

Federal Status: Endangered

Description: Bartram's scrub-hairstreak is a small gray butterfly with white and orange markings. Pineland croton is the only known hostplant (same for Florida leafwing) in pine rocklands. Bartram's scrub-hairstreak adults are seen most often feeding on the nectar of pineland croton. As a result, this species is typically only found within 5 meters of host plant.

Bartram's scrub hairstreak. Photo by Holly Salvato

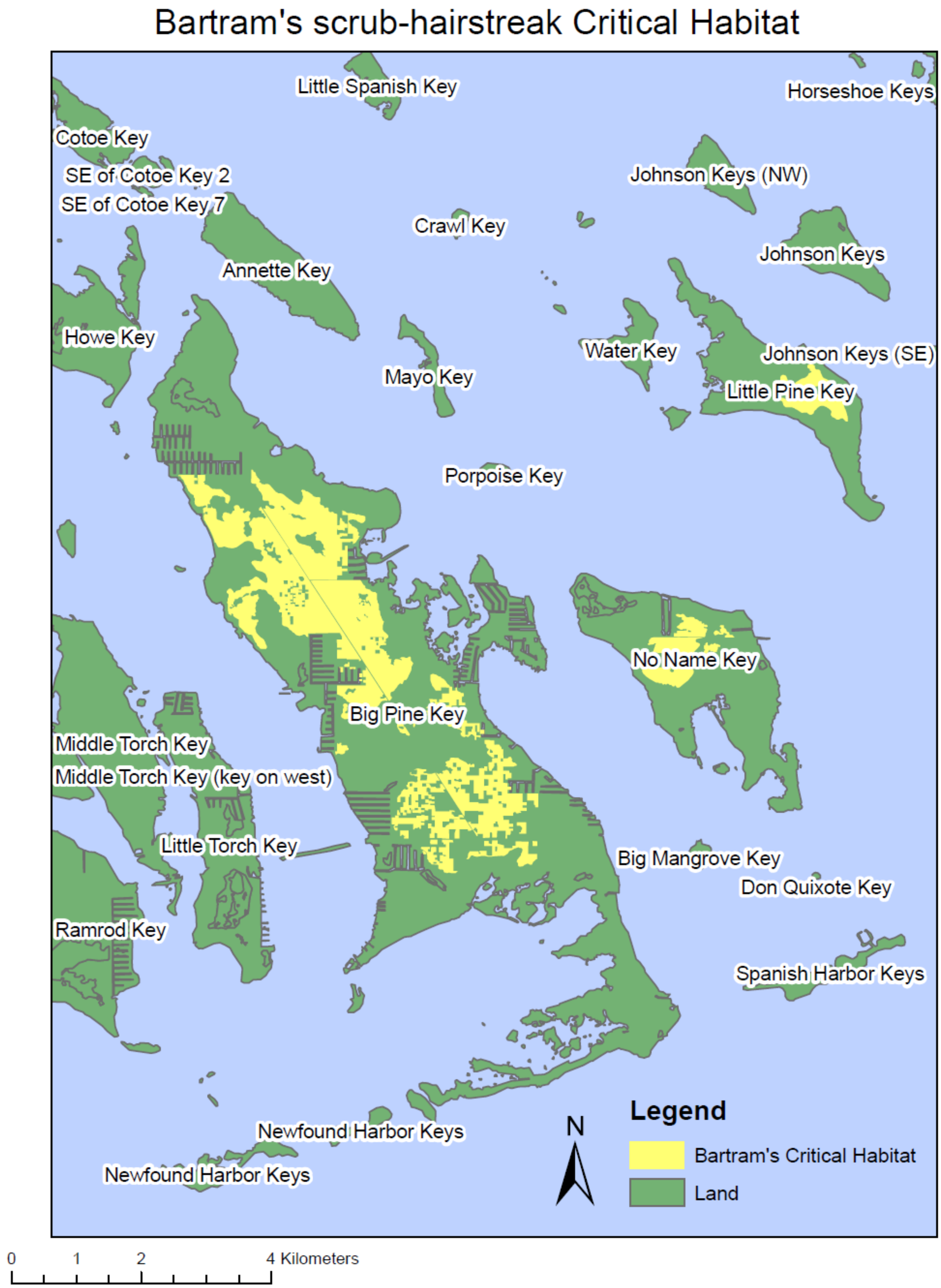


Figure 6.9 Critical habitat of the Bartram's scrub-hairstreak butterfly. This map represents potential distribution, and not the known distribution of the Bartram's scrub-hairstreak butterfly. This map was provided by the McGuire Center for Lepidoptera and Biodiversity.

Map Comments:

1) The Bartram's Scrub-Hairstreak in the Keys is only found on Big Pine Key and it is close to extinction there. The other islands that were designated as critical habitat for Bartram's Scrub-Hairstreak are wishful thinking because the larval host plant no longer occurs on those other islands, if it ever did.

Table 6.9. Bartram's scrub-hairstreak results. The contents of this table represent the information generated during workshop exercises. The contents of the first three rows are the recommendations of participants of Workshop 1, while the contents of row 4 are the priority actions determined by participants of Workshop 2.

Consequences of Sea Level Rise	• Without management, won't be extant long. May lose before sea levels rise • SLAMM does not delineate between upland habitat types So it is hard to know relative impacts of different levels of sea level rise • Extinction is likely for the Keys population at 2 ft. of sea level rise, even with proper habitat management o 1 ft. may be ok o 2 ft. probable habitat lost - pine rockland
Proposed Adaptation Actions	• Any management actions in the Keys need to be undertaken in the mainland as well • Protecting & managing pine rocklands must be a priority, especially on the mainland • This team feels that creating new pine rocklands is not currently possible • Out-of-the-box idea = potential translocation to pine rocklands in the Bahamas. Would require a lot of research and work.
Trigger Points and Monitoring	• Immediate burning is needed – trigger point is now • Host plant enhancement is a now action • Design and implement monitoring of adult butterflies • Management needs to shift immediately to prescribed fire, pre-fire thinning/mechanical clearing, rather than fire suppression • This should provide a pilot project for the USFWS • Continuity of permanent staff with adaptation measures
Priority Actions	Now • Continue host plant reintroductions. Prioritize for high elevation areas • Prescribed fire and mechanical habitat restoration Future – Trigger may be now • Increased habitat management and host plantings

6.10 MIAMI BLUE BUTTERFLY

(*Cyclargus thomasi bethunebakeri)*

Federal Status: Endangered

Description: The Miami blue butterfly is a small brightly colored butterfly endemic only to South Florida. This species can be found in tropical hardwood hammocks, pine rocklands, and beachside scrub. It can utilize multiple hostplants, including balloonvine (*Cardiospermum spp*.), gray nickerbean (*Caesalpinia bonduc*), and blackbead (*Pithecellobium spp.*). Once locally abundant, its populations exist in the low 100s.

Miami blue butterfly. Photo by Mary Salvato.

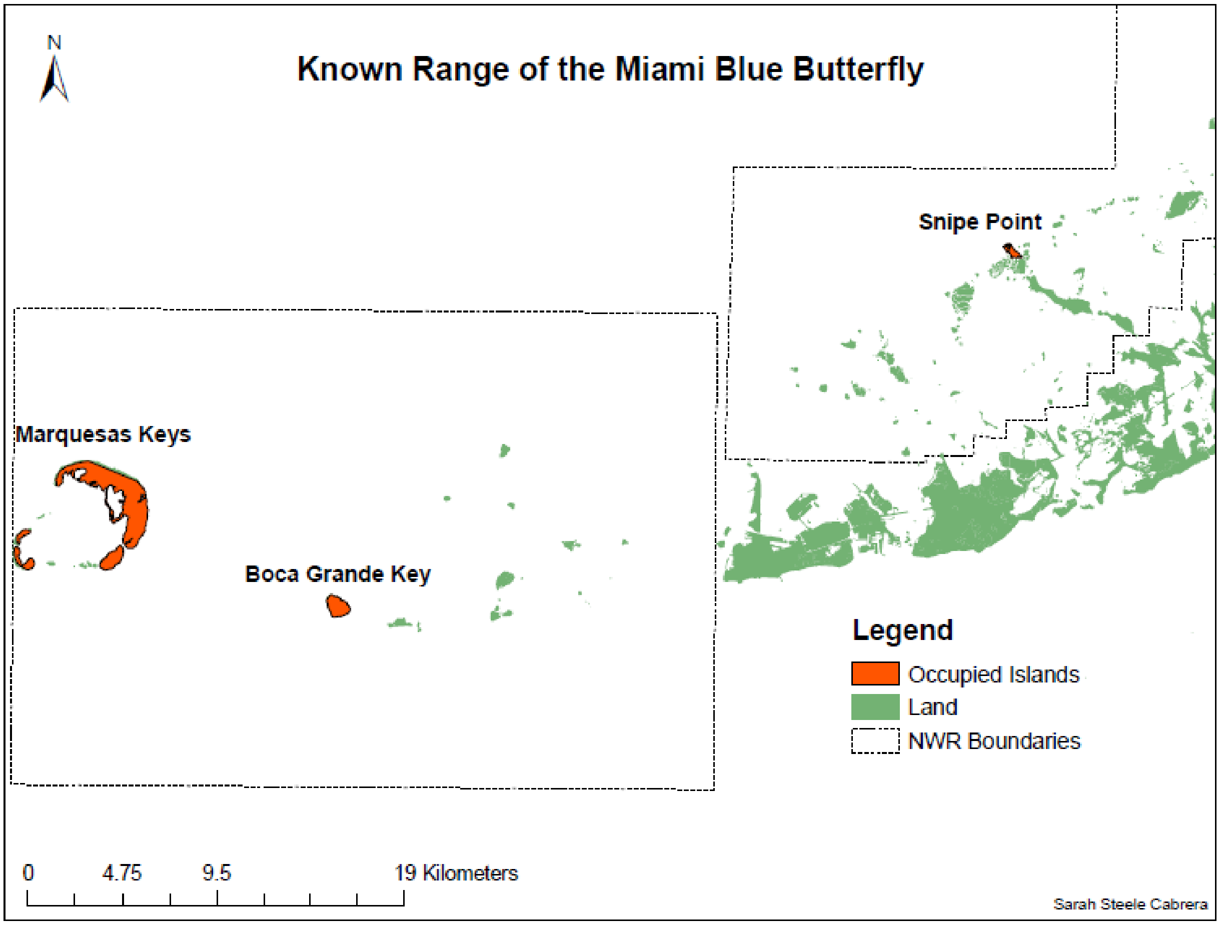


Figure 6.10. Known range of the Miami blue butterfly. This map was provided by the McGuire Center for Lepidoptera and Biodiversity.

Map Comments:

None

Table 6.10 Miami blue butterfly results. The contents of this table represent the information generated during workshop exercises. The contents of the first three rows are the recommendations of participants of Workshop 1, while the contents of row 4 are the priority actions determined by participants of Workshop 2.

Consequences of Sea Level Rise	• Maps don't include Marquesas, need extended view to determine extend SLAMM • Multiple host plants create additional adaptability • Ability of butterfly to live in several habitats could give additional resiliency • Possible susceptible to stochastic events like storms • Role of erosion is critical. Habitat is likely 6 ft., but quality habitat will likely vanish before 6 ft. of sea level rise o 1 ft.

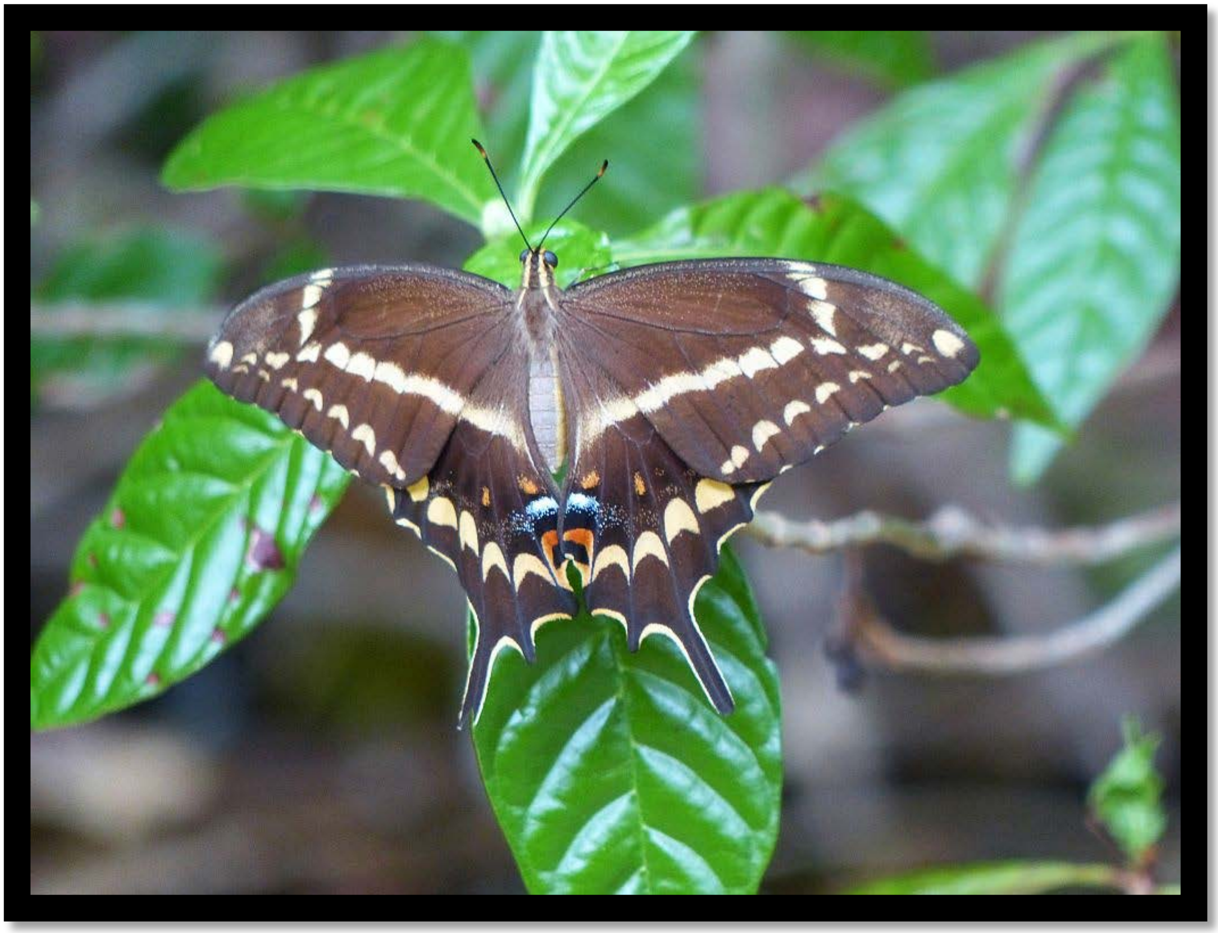
	2 ft. upland habitat may still exist 3 ft. habitat will likely not exist 4 ft. alongside storms this sea level would be damaging to any remaining populations
Proposed Adaptation Actions	• Reintroductions have already begun and should continue • Reintroduction sites should be chosen to take sea level rise into account • There is need to research into life history to inform reintroductions- this process has already begun
Trigger Points and Monitoring	• Developing criteria for reintroduction site selection • Post-reintroduction monitoring of released individuals • At 1 ft. of sea level rise, prioritize reintroduction sites in the mainland
Priority Actions	Now • Important to determine original range – Map needed for decision making • Within Keys: plant on high ground, no spraying where host plants exist, or could be • Host plants to be incorporated to restoration projects, development landscaping, and potentially private landscaping • Increase education and nursery availability for host plants • Increase populations to get off list, then extend range in Keys (potential sites: Lignum Vitae Key, Key Largo, Big Pine Key) • Future may be on the mainland

6.11 SCHAUS SWALLOWTAIL BUTTERFLY

(Strymon acis bartrami)

Federal Status: Endangered

Description: The Schaus swallowtail butterfly is a large black-brown butterfly with yellow, blue, and rust colored markings. This butterfly is endemic only to the Florida Keys, where only a few hundred adults remain. This species is associated with tropical hardwood hammocks, where it hosts on torchwood (*Amyris elemifera*) and occasionally wild lime (*Zanthoxylum fagara*).



Schaus swallowtail butterfly. Photo by Susan Kolterman.

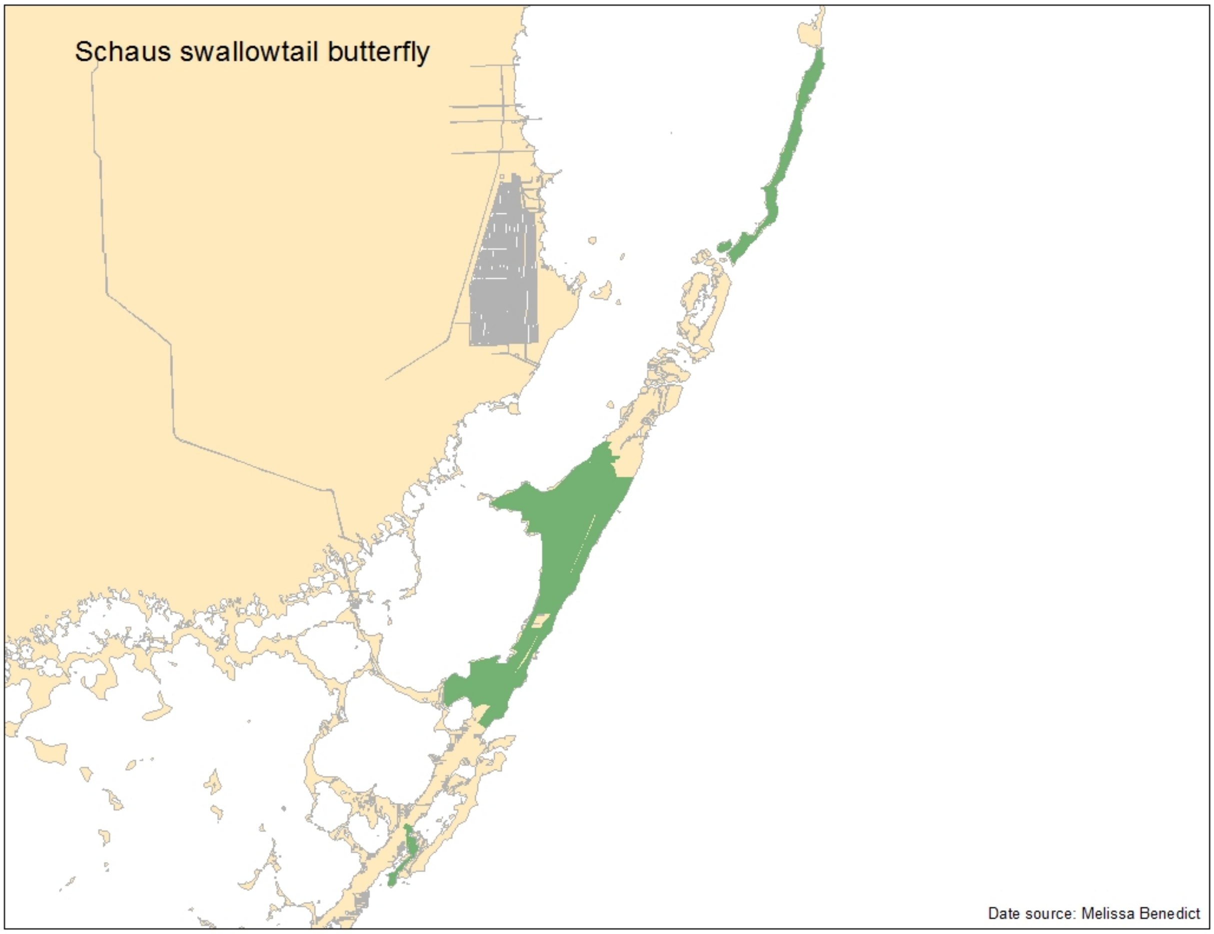


Figure 6.11 Known range of the Schaus swallowtail butterfly. This map was generated with information provided by the McGuire Center for Lepidoptera and Biodiversity by Melissa Benedict.

Map Comments:

1) Map is only showing islands in the Upper Keys where it has been seen in recent times, yet all the islands with hardwood hammocks from Biscayne National Park southward to Key Largo are potential habitat. Those islands have not been surveyed very well because they are so hard to get to and it's easy to get lost in the woods without any trails.

Table 6.11. Schaus swallowtail results. The contents of this table represent the information generated during workshop exercises. The contents of the first three rows are the recommendations of participants of Workshop 1, while the contents of row 4 are the priority actions determined by participants of Workshop 2.

Consequences of Sea Level Rise	• Range is just upland hammock • North Key Largo: Even at 4ft habitat is likely to persist, but might be more confined to interior so total available habitat would be smaller. • Effects of future drought could be significant • Currently highest numbers are on Elliot Key where 3 ft. would cause loss of habitat

	• On Adams Key lose upland between 2-3 ft. and is totally gone at 4.
	• Likely hosts will disappear when roots become inundated
	  o 1 ft. still ok
	  o 2 ft. Adams Key habitat reduced
	  o 3 ft. Adams Key habitat reduced. Elliot Key loss of habitat
	  o 4 ft. Adams Key habitat gone. Key Largo habitat persists

Proposed Adaptation Actions	• Habitat will be significantly reduced but still present at 4 feet of sea level rise • Currently FL State Park policy does not allow for introductions, but translocations to areas such as Windly Key could be valuable • Translocation of Upper Keys hammocks on non-state park land is a possibility • Mosquito spraying is a major factor to be considered in Key Largo and in the Upper Keys • Success of reintroduction and augmentation efforts is not known, and we need to better understand these efforts • Understanding life history and reintroductions success is important • Habitat management (invasive removal, etc.) to give this butterfly a better chance of resilience to sea level rise • Two larval host plants give this butterfly additional adaptability • Highest priorities are procurement and management of habitat within historic range • Management via mechanical trimming to open the canopy and mimic disturbance • Continuity of permanent staff with adaptation measures
Trigger Points and Monitoring	• Host plant enhancement is a now action • Design and implement monitoring of adult butterflies • Increase survey effort to better capture 2nd flight in August/September
Priority Actions	Now – Trigger already reached • Host plant enhancement to continue; Planting in higher elevations and spray free areas • Captive rearing and breeding program • Manage habitat with mechanical trimming to open habitat Future recommendations

	• Increased host planting efforts – consider private lands • Reintroduce to mainland • Research to fill life history gaps, and mortality in reintroductions, and population viability • Explore funding for adult monitoring

6.12 STOCK ISLAND TREE SNAIL

(*Orthalicus reses)*

Federal Status: Threatened

Description: The Stock Island tree snail is a large terrestrial snail that is typically found on the trunks of trees within tropical hardwood hammocks. Specifically, the tree snail prefers habitat with smooth barked trees where it can feed on lichen, moss, and other biofilm. The Stock Island tree snail was once exclusively found on the lower Keys, where it is now extirpated. Now this tree snail can only be found on the northern Keys, where it has been introduced.

Stock Island tree snail. Photo by Sara Hamilton of Florida Keys Electric Cooperative (FKEC).

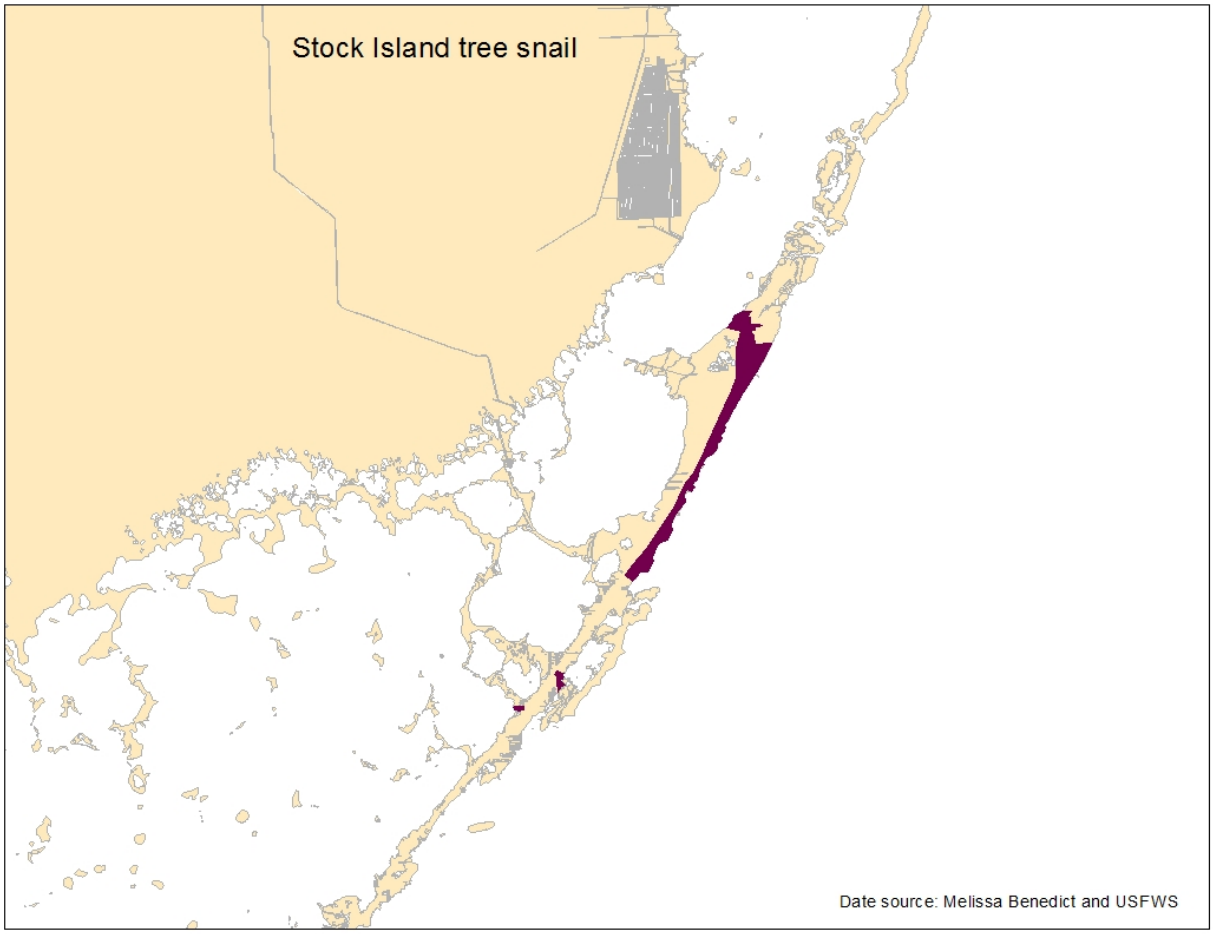


Figure 6.12. Known range of the Stock Island tree snail. This map was generated by Melissa Benedict with information provided by US Fish and Wildlife Service.

Map Comments:
None

Table 6.12. Stock Island tree snail results. The contents of this table represent the information generated during workshop exercises. The contents of the first three rows are the recommendations of participants of Workshop 1, while the contents of row 4 are the priority actions determined by participants of Workshop 2.

Consequences of Sea Level Rise	• There is concern that as habitat on North Key Largo constricts, the closely related Orthalicus resus resus may outcompete liguus. • Other climate factors (reduced precipitation) may impact this species more than sea levels • Invasive flatworms are impacting this species • The main population is in North Key Largo, and these consequences are intended for that area

	• Unlikely to survive sea level rise on Stock Island (if any remain), but areas of North Key Largo where they were previously introduced should be okay at 4 ft. of sea level rise. o 1 ft. slight reduction in habitat o 2 ft. slight reduction o 3 ft. slight reduction o 4 ft. still have habitat though likely reduced
Proposed Adaptation Actions	• The full extent of the population range and size is not known, therefore research is needed • Mosquito spraying is likely to have adverse effects, so identifying strongholds is important • Sea level rise may not be as dire as some other impacts to the species, so addressing other issues may come first
Trigger Points and Monitoring	• Full range-wide survey needed to determine population size and distribution • Study needed to examine interspecies interactions • Monitoring needed of proper hammock and leaf litter • Information needed for reintroductions of population size and patch size • Monitoring needs for precipitation patterns and temperature changes
Priority Actions	Now – Trigger is now • Support populations in Key Largo • Survey of population extent/range needed to identify strongholds and possible reintroduction sites • Monitoring needed Future recommendations • Reintroductions on Stock Island or Key West where habitat is suitable • Explore introductions outside historic range in Keys where habitat is suitable • Seek methods to control invasive flatworms

6.13 ROSEATE TERN
(*Sterna dougallii dougallii)*

Federal Status: Threatened

Description: This species is a mid-sized tern that can reach a length of 15.7 inches (40 centimeters) with a wingspan of 23.6 inches (60 centimeters) (U.S. Fish & Wildlife Service 1999). This species has a black cap, gray back, white underside, white forked tail, and a thin black bill which becomes red during the breeding season (Florida Natural Areas Inventory 2001). They nest in broken coral deposits, bare limestone, shell/sandy beaches, newly deposits of mudstone and rock, and rooftops. This species can be found from Nova Scotia, south to the Florida Keys, and on islands throughout the Caribbean. Their diet primarily consists of small fish (ex. sand lance, hake, and herrings) and some invertebrates.

Roseate tern. Photo provided by Florida Fish and Wildlife Conservation Commission.

Figure 6.13. Known range of the roseate tern. This map was provided by Florida Fish and Wildlife Conservation Commission.

Map Comments:

None

Table 6.13. Roseate tern results. The contents of this table represent the information generated during workshop exercises. The contents of the first three rows are the recommendations of participants of Workshop 1, while the contents of row 4 are the priority actions determined by participants of Workshop 2.

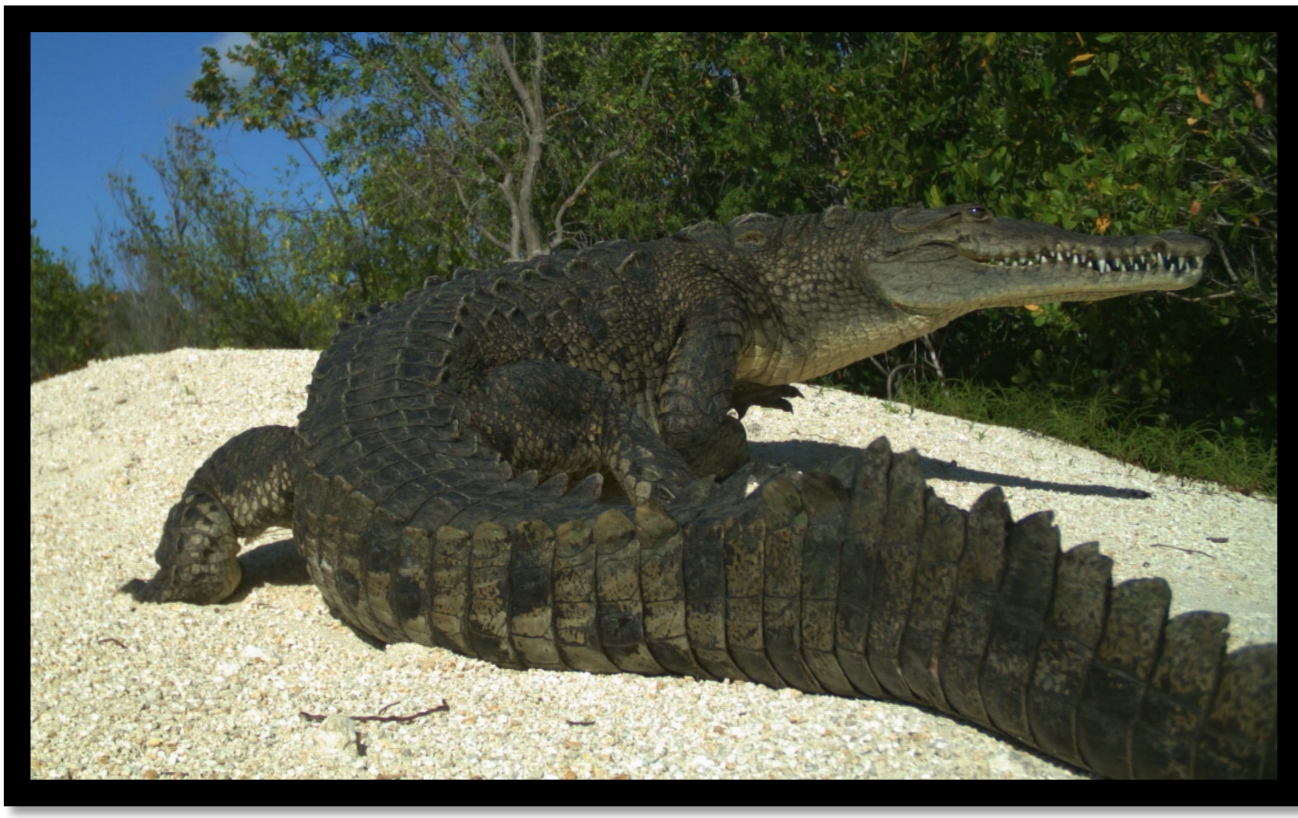
Consequences of Sea Level Rise	• Uncertainty modeling beaches combine with human activity/influence may make it difficult to predict impacts • As additional homes and island are abandoned, tern nesting may improve • Some inundated habitat may improve habitat/create new habitat for terns

	o 1 ft. o 2 ft. Tortugas nesting sites are gone o 3 ft. o 4 ft.
Proposed Adaptation Actions	• Create floating platforms with proper laying/nesting medium • Metal bridges can be filled in with gravel to create nesting habitat that is far from sea level rise • Need more multi-agency support to modify and promote existing bridges/structures for nesting sites
Trigger Points and Monitoring	• Trigger point is now
Priority Actions	Now • Continue current actions • Explore modification/creation of nesting sites where possible

6.14 AMERICAN CROCODILE
(Crocodylus acutus)

Federal Status: Threatened

Description: The American crocodile is a large grey crocodilian that is associated with coastal estuarine marshes, tidal swamps, and creek edges, and are most typically associated with mangrove. A major limiting factor in their population size is availability of nesting sites. Crocodiles are known to nest on beaches, stream banks, and levees, but require nearby nursery habitat for hatchling success.



American crocodile. Photo provided by USFWS

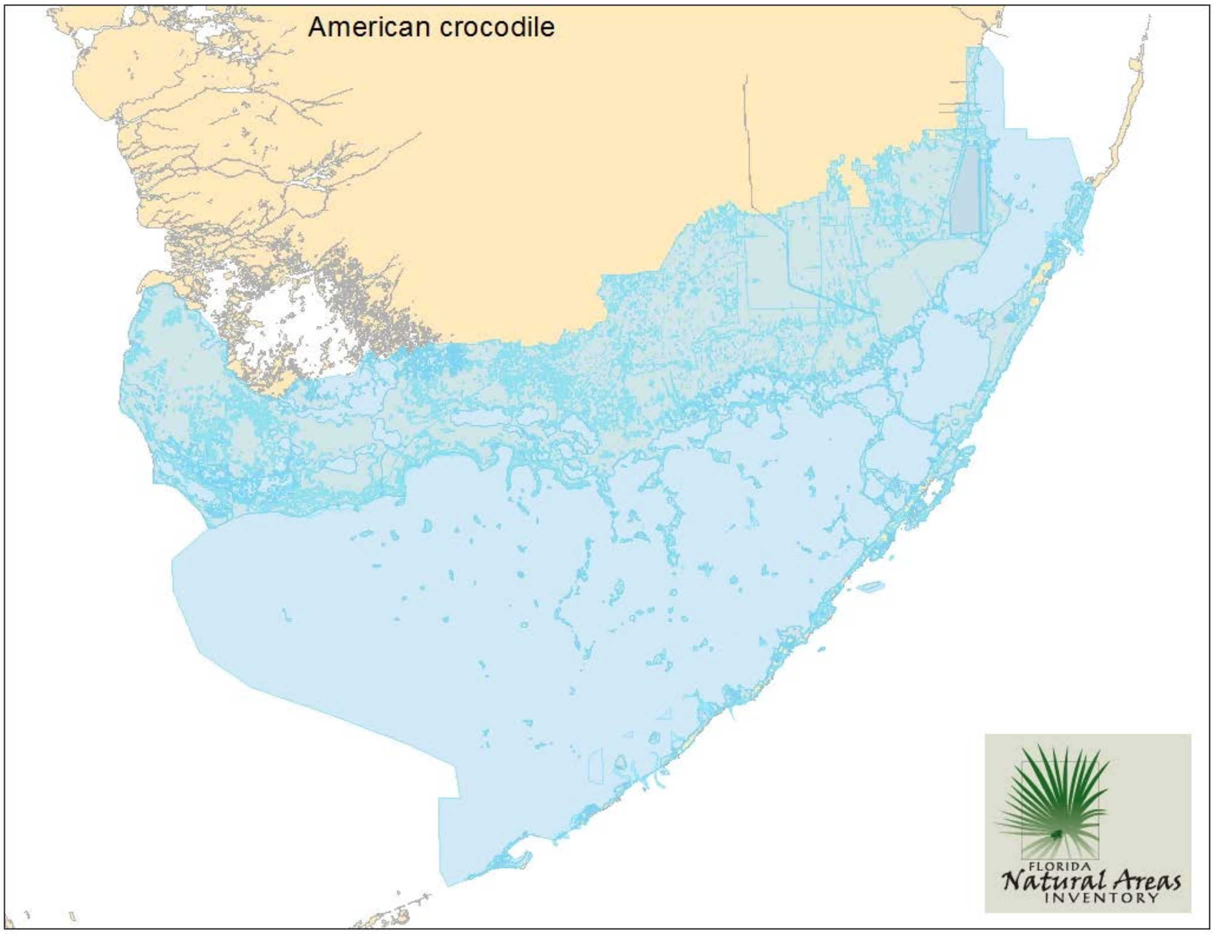


Figure 6.14 Known distribution of the American crocodile. This map was produced by Florida Natural Areas Inventory.

Map Comments:

1) East coast should extend to Dania Cutoff Canal on East Coast and Sanibel Island on West Coast.
2) Crocodiles have been as far south as Sugarloaf Key.

Table 6.14. American crocodile results. The contents of this table represent the information generated during workshop exercises. The contents of the first three rows are the recommendations of participants of Workshop 1, while the contents of row 4 are the priority actions determined by participants of Workshop 2.

Consequences of Sea Level Rise	• Failed nesting and they don't commonly relocate • April & May reproductive season – tied with rainy season • Sex ratios may be altered • Road mortality may increase with sea level rise. Roads are high points • Sensitive to cold temperatures

	1 ft. 2 ft. 3 ft. 4 ft.
Proposed Adaptation Actions	- Need to build new nesting areas - Create artificial islands for floating nest sites that are adaptable to rising seas - Remove eggs from nesting sites for artificial incubation - Sea level rise could potentially open new habitat (no action required) - Shade some nesting areas to increase the number of females hatching - Continue to bring in sand for nesting (robust)
Trigger Points and Monitoring	- Trigger points may have already occurred as reproduction failure is already occurring - Build higher nesting sites now - Incubate eggs - Provide shading support for healthy sex ratios and monitor sex ratios - At 2 ft. artificially maintain substrate between islands and floating islands
Priority Actions	Now – Trigger is now - Habitat enhancement through the creation of nesting sites - Validate assumption that nesting/occupancy is expanding Future recommendations - Monitor nesting success and sex ratios - Continue to create nesting sites - Identify further areas to improve nesting sites - Utilizing sea level rise models, determine likely areas for future habitat nesting

6.15 EASTERN INDIGO SNAKE
(Drymarchon couperi)

Federal Status: Threatened

Description: The eastern indigo snake is associated with a range of habitat types, including: Pine flatwoods, scrubby flatwoods, high pine, dry prairie, tropical hardwood hammock, edges of freshwater marsh, coastal areas, and human-altered habitat. However, it requires freshwater for survival in these habitats. This species also requires sheltered areas to escape cold conditions.

Eastern indigo snake. Photo by Kevin Enge of FWC.

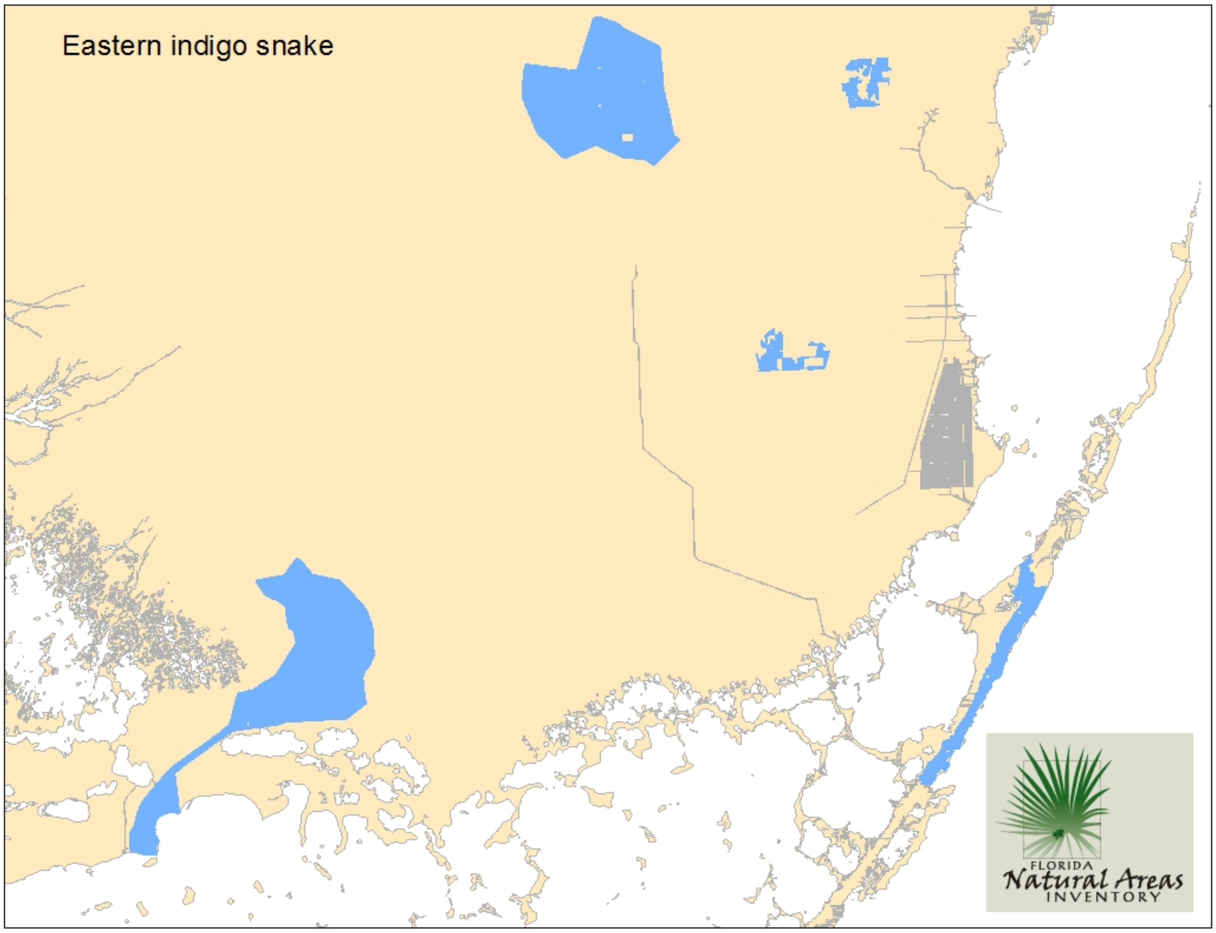


Figure 6.15. Known range of the eastern indigo snake. This map was produced by Florida Natural Areas Inventory.

Map Comments:

1) The area around Turkey Point (power plant site) south and west through the model lands to SR 905.

2) The last official record of the eastern indigo snake in the Keys was a roadkill on Key Largo in 1998. Road mortality and probably some killing by people and dogs were undoubtedly responsible for the disappearance of this species, which has a large home range size and is susceptible to habitat fragmentation. However, in 2009, the only resident on Little Knockemdown Key, sent a photo of an indigo drinking from a water dish set out for birds. Since then, the owner has provided additional photos. This is a roadless key, and other keys are nearby.

Table 6.15. Eastern indigo snake results. The contents of this table represent the information generated during workshop exercises. The contents of the first three rows are the recommendations of participants of Workshop 1, while the contents of row 4 are the priority actions determined by participants of Workshop 2.

Consequences of Sea Level Rise	• Hardly any recent sightings
	• Its absence could contribute to python problem
	• Collapse of rodent species reduced other snake populations
	• Within the 2 documented sightings
	  o 1 ft.
	  o 2 ft. would limit most habitat in the lower keys
	  o 3 ft.
	  o 4 ft. some habitat still intact in upper keys

Proposed Adaptation Actions	• Translocation pilot project to determine how viable translocation is • Augmentation of populations possible • Focus on higher elevation habitat areas that survive 4 ft. of sea level rise • Need a better understanding of populations, but we currently do not have a good way of detecting them • Efforts may be better directed elsewhere as the Keys are marginal habitat and we have lots of information gaps
Trigger Points and Monitoring	• Continue to monitor and look for populations
Priority Actions	Now • Focus efforts outside of Keys

6.16 KEY DEER

(Odocoileus virginianus clavium)

Federal Status: Endangered

Description: The Key deer is a small subspecies of the white-tailed deer. They live on approximately 20 islands in the middle Keys. This small deer is associated with pine rockland, tropical hardwood forests, and mangrove transition zones in the Middle Keys. These deer have little to no fear of humans, and can frequently be found feeding in developed areas.

Key Deer. Photo by USFWS.

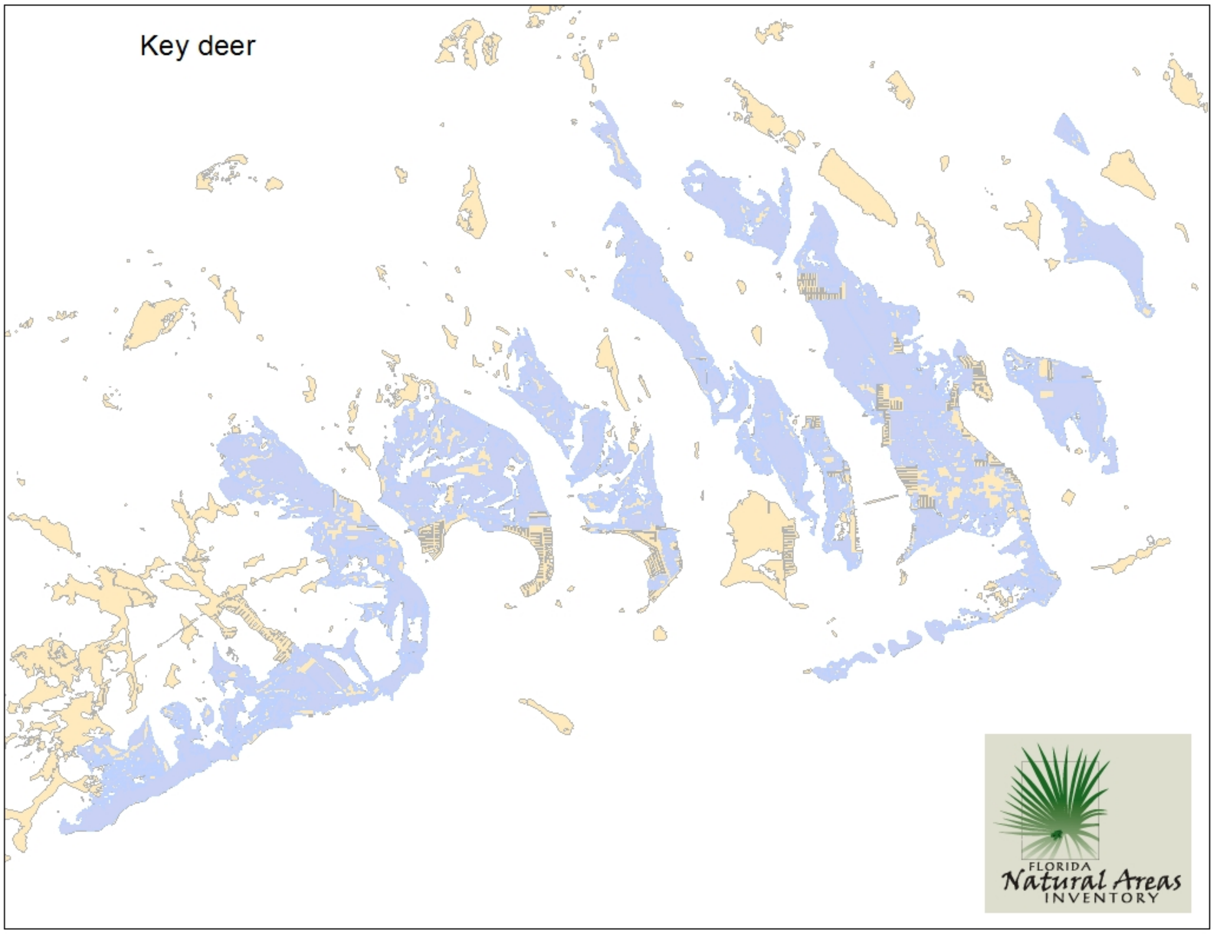


Figure 6.16. Known distribution of the Key deer. This map was provided by the Florida Natural Areas Inventory.

Map Comments:
None

Table 6.16. Key deer results. The contents of this table represent the information generated during workshop exercises. The contents of the first three rows are the recommendations of participants of Workshop 1, while the contents of row 4 are the priority actions determined by participants of Workshop 2.

Consequences of Sea Level Rise	• Even at 1 ft. key deer lose 37% of freshwater • Inbreeding depression • Freshwater availability is the major issue • One major salinization event could wipe out freshwater access • Could tolerate fragmentation if freshwater access is available o 1 ft. 37% loss of freshwater o 2 ft. freshwater likely lost/compromised o 3 ft.

	o 4 ft.
Proposed Adaptation Actions	• Fires management and logistics is the major critical need • Freshwater is a major issue, so creating sources for deer will be important o Rain water retention improvement o Pumping freshwater to the surface o Create artificial ponds to retain water • Consider other islands to relocate Key deer
Trigger Points and Monitoring	• Establish captive populations now • Monitor the salinity levels of freshwater resources. Trigger points will trigger placement of permanent artificial watering sources • Monitor the number and quality of freshwater sources • Now: establish and position emergency freshwater sources • Population trigger point may be 200 to 300 individuals to trigger more active supplementation of food or water • 2 ft. of sea level rise we will lose 50% of habitat, would trigger more active intervention
Priority Actions	Now • Maintaining freshwater resources is high priority: Identify most vulnerable freshwater sources, monitor salinity, and set trigger points for artificial watering • See if Bureau of Land Management has possible guzzler tech that could be used • Provide freshwater short term when loss occurs

6.17 KEY LARGO COTTON MOUSE

(Peromyscus gossypinus allapaticola)

Federal Status: Endangered

Description: The Key Largo cotton mouse is a small mouse associated with the tropical hardwood hammocks of Key Largo, and can be found in varying successional stages of the hammocks. This species is endemic to the northern Keys, but due to development pressures it can only be found in the northern most protected forests of Key Largo.

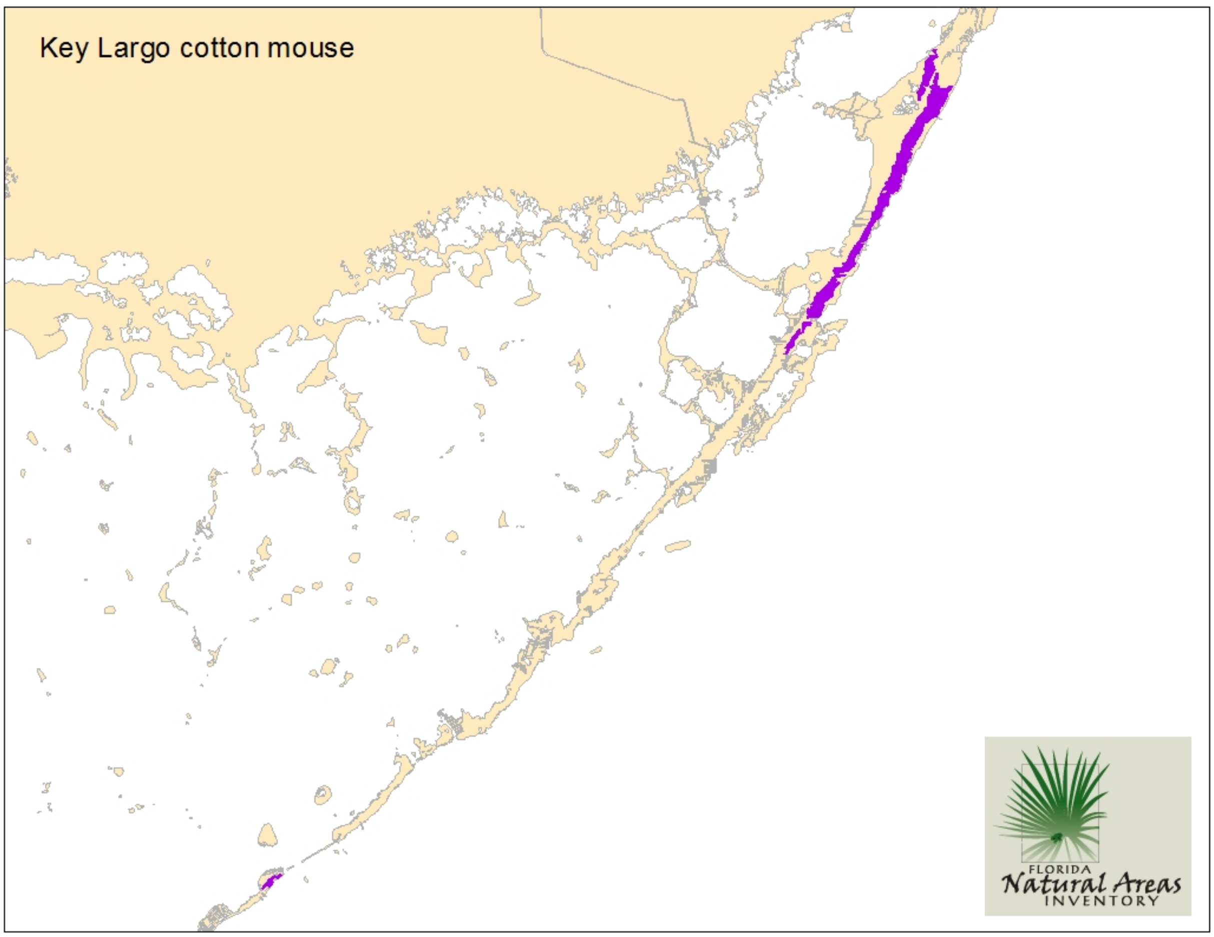


Figure 6.17 Known distribution of the Key Largo cotton mouse. This map was provided by the Florida Natural Areas Inventory.

Map Comments:

1) The distribution map shows the Key Largo cotton mouse (KLCM) as being present at the land base on Lignumvitae Key Botanical State Park to the south. There are no KLCM there (a failed introduction).

2) The range for KLCM goes too far south on Key Largo. Just to the east of US 1 entering Key Largo is Garden Cove Drive. Cotton mice have been captured in the parcel between Garden Cove and Loquat Drive. Trapping has been done further south, including that parcel highlighted south of Andros Road, but only nonnative Black Rats were captured.

Table 6.17. Key Largo cotton mouse results. The contents of this table represent the information generated during workshop exercises. The contents of the first three rows are the recommendations of participants of Workshop 1, while the contents of row 4 are the priority actions determined by participants of Workshop 2.

Consequences of Sea Level Rise	• Habitat mostly intact at 4 feet of sea level rise
	• Pinch points (mangrove hits roads) emerge clearly between 3 and 4 feet sea level rise
	  o 1 ft.
	  o 2 ft. habitat constrained
	  o 3 ft. habitat constrained
	  o 4 ft. alongside storms would be damaging

Proposed Adaptation Actions	• At 1 ft.
	  o Identifying fresh water refugia
	  o Improve habitat quality outside of existing range in Key Largo
	  o Manage feral cats and pythons, maybe fencing off areas
	  o Create supplemental nesting sites
	  o Research needs: Optimal habitats, critical minimums for populations, and density tolerances
	• Higher sea level rise
	  o Mitigate migration barriers at higher increments of sea level rise
	  o Maintain or improve canopy roads
	  o Increase new nests so that population density increases as habitat decreases
	  o Education campaign needed for feral cat control and outdoor cats
	  o Low cost habitat acquisitions need to be identified
	  o Easements for responsible cat ownership

Trigger Points and Monitoring	
Priority Actions	Now • Nesting habitat enhancement

	• Invasive predator control Future recommendations • Increase habitat enhancement • Continue or increase trapping of invasive predators – cat exclosures • Mitigate migration barriers • Habitat mosaic research – to open hammock

6.18 KEY LARGO WOODRAT
(Neotoma floridana smalli)

Federal Status: Endangered

Description: The Key Largo woodrat is large rat associated with the tropical hardwood hammocks of northern Key Largo. It requires vegetative matter from these hammocks as the basis of its nest building material, which it builds at the base of trees, stumps, and rockpiles. Habitat loss and fragmentation are the greatest threat to this species.

Key Largo woodrat. Photo by Clay DeGayner

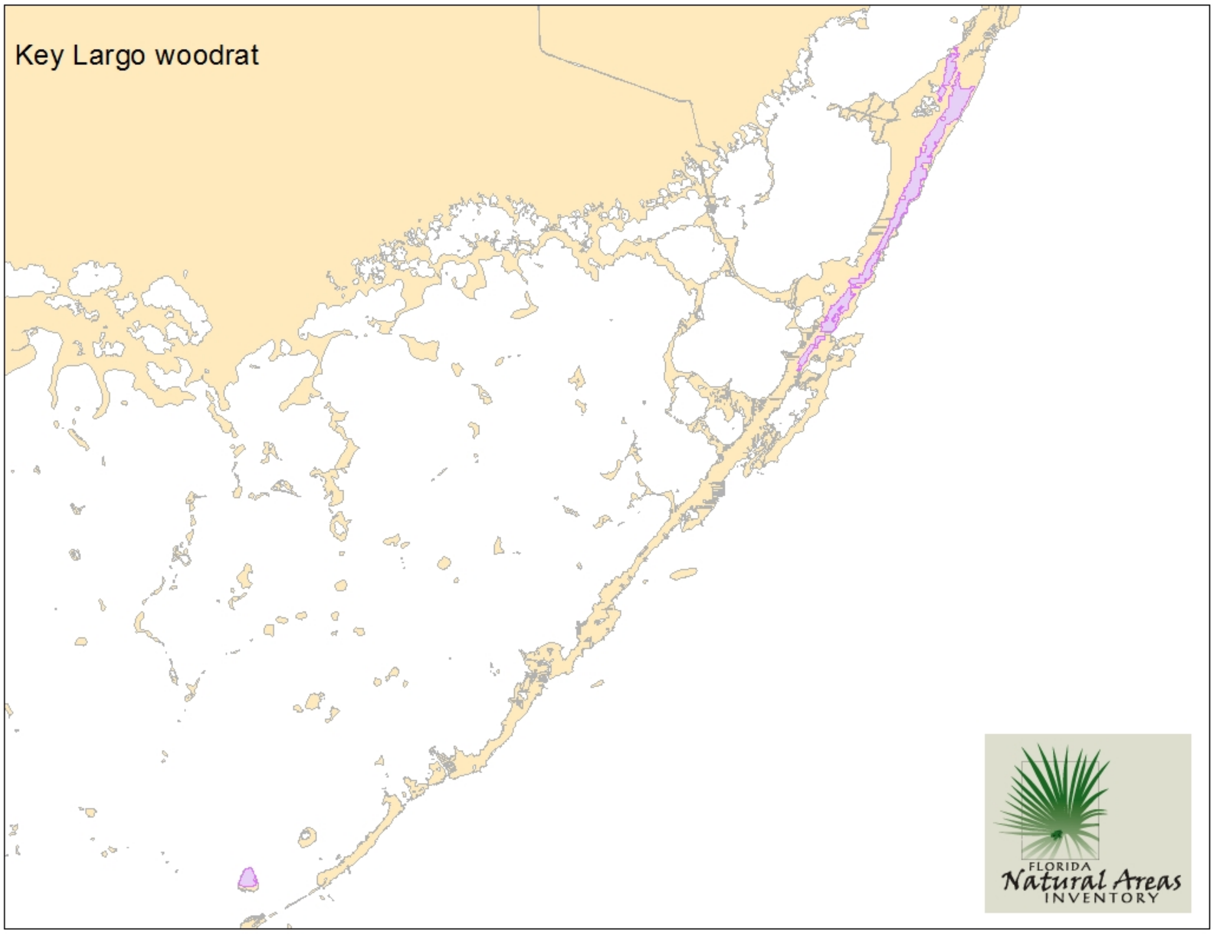


Figure 6.18 Known distribution of the Key Largo woodrat. The map was produced by the Florida Natural Areas Inventory.

Map Comments:

1) The distribution map shows the Key Largo woodrat as being present on Lignumvitae Key to the south. There are no Key Largo woodrats on that island (a failed introduction). Regarding that introduction, the island has been trapped several times over the past few decades and neither KLCM nor KLWR were captured.
2) Also, the Key Largo distribution goes further south than it should. Just to the east of where US 1 makes the turn into the island is Loquat Drive. I do not believe woodrats have been reported south of Loquat Drive (but the Refuge would know for sure).

Table 6.18. Key Largo woodrat results. The contents of this table represent the information generated during workshop exercises. The contents of the first three rows are the recommendations of participants of Workshop 1, while the contents of row 4 are the priority actions determined by participants of Workshop 2.

Consequences of Sea Level Rise	• Very like cotton mouse
	• Appropriate habitat limited by cats
	• Diet generalists
	• Southern limit mile marker 106
	• Python migration may be significant non-climate stressors
	• Likely habitat available up to 4 ft., though severely reduced
	  o 1 ft.
	  o 2 ft.
	  o 3 ft.
	  o 4 ft.

Proposed Adaptation Actions	• At 1 ft.
	  o Identifying fresh water refugia
	  o Improve habitat quality outside of existing range in Key Largo
	  o Manage feral cats and pythons, maybe fencing off areas
	  o Create supplemental nesting sites
	  o Research needs: Optimal habitats, critical minimums for populations, and density tolerances
	• Higher sea level rise
	  o Mitigate migration barriers at higher increments of sea level rise
	  o Canopy roads
	  o Increase new nests so that population density increases as habitat decreases
	  o Education campaign needed for feral cat control and outdoor cats
	  o Low cost habitat acquisitions need to be identified now
	  o Easements for responsible cat ownership

Trigger Points and Monitoring	
Priority Actions	Now • Nesting habitat enhancement • Invasive predator control Future recommendations • Increase habitat enhancement

	• Continue or increase trapping of invasive predators – cat exclosures • Mitigate migration barriers • Identify additional reintroduction locations (Elliot Key, possibly other Key Largo locations)

6.19 LOWER KEYS MARSH RABBIT
(Sylvilagus palustris hefneri)

Federal Status: Endangered

Description: The Lower Keys marsh rabbit is found primarily in grassy marsh and prairie habitats of the Lower Florida Keys. This species depends upon freshwater marshes and the transitional zone between grasses and sedges. The marsh rabbit can also be found in the mangrove transition zone.

Lower Keys marsh rabbit. Photo by Chad Anderson of USFWS

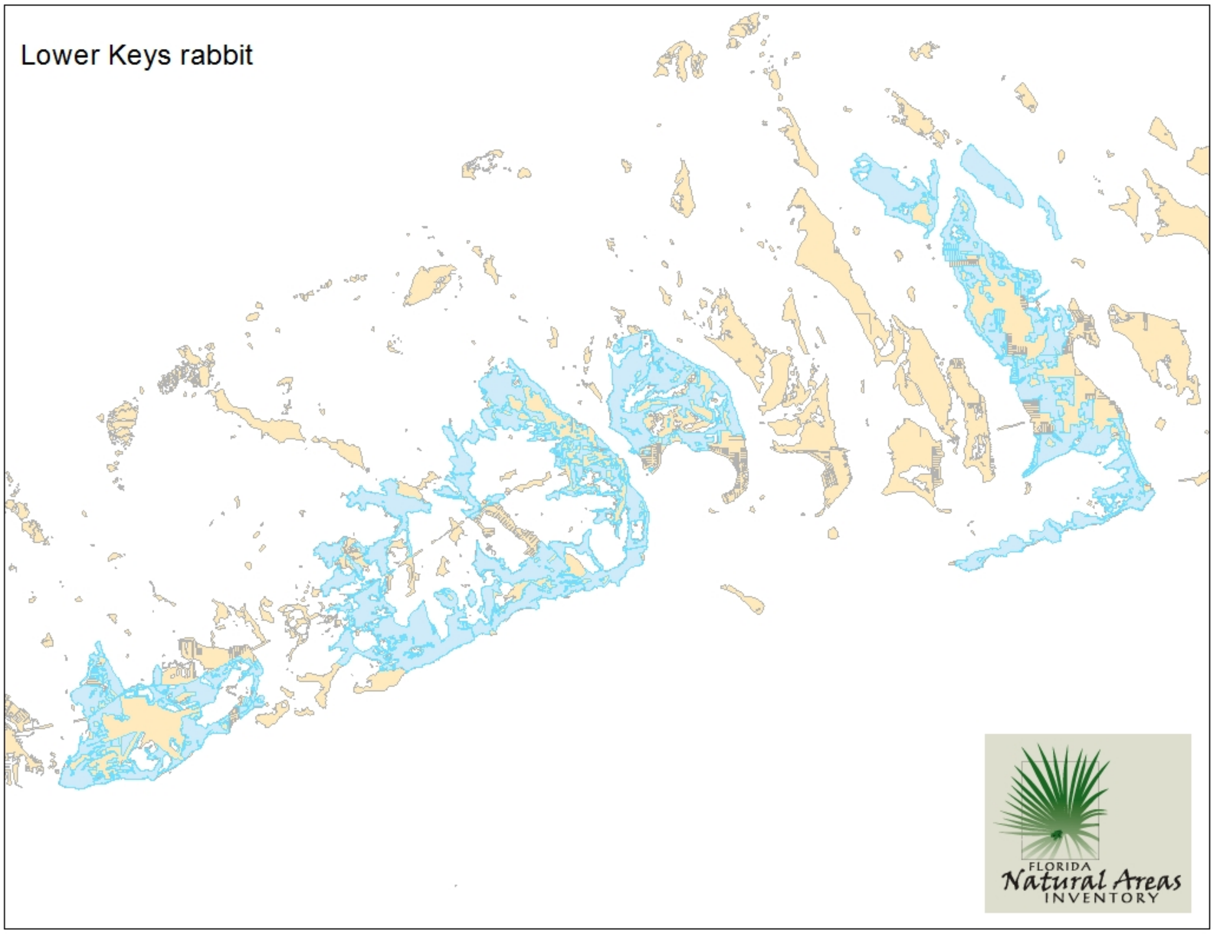


Figure 6.19. Known distribution of the Lower Keys marsh rabbit. This map was produced by the Florida Natural Areas Inventory.

Map Comments:

None

Table 6.19 Lower Keys marsh rabbit results. The contents of this table represent the information generated during workshop exercises. The contents of the first three rows are the recommendations of participants of Workshop 1, while the contents of row 4 are the priority actions determined by participants of Workshop 2.

Consequences of Sea Level Rise	• Need better understanding of the hydrology • High tides and salt water intrusion will affect coastal habitat – Big Pine Key • May be able to retreat to mangroves, will need more information on how they survive in mangroves to better understand impacts • One major salinization event could wipe out freshwater access

	• Herbaceous salt marsh may be transitioning into rocky intertidal habitat, which is not ideal • Loss of pine sediment may be a problem o 1 ft. o 2 ft. freshwater decline o 3 ft. further decline o 4 ft. Most freshwater lost
Proposed Adaptation Actions	• Cats are a major issue and need to be addressed, FWC needs priority action on cats • Improve core habitat conditions • Fill in mosquito ditches • Restore more normal standing freshwater regimes to improve marshes • Identify and prioritize most critical locations • Similar issues to Key deer in terms of removal • Control predators such as cats and pythons • Leverage money to spend on military infrastructure to conserve and improve habitat. Utilize equipment military is using to improve infrastructure to create new habitat on the military land
Trigger Points and Monitoring	• When population drops to 50%, focus on increasing habitat quantity/quality (monitor via pellet counts & population size) • When Navy announces plans to elevate runways, this should trigger elevating marsh rabbit habitat
Priority Actions	Now • Prioritize which mosquito ditches to fill for habitat benefit • Focus on keeping cats out of wild areas • Use any infrastructure raisings or changes to artificially create new habitat – proven to work

6.20 RICE RAT

(Oryzomys palustris natator)

Federal Status: Endangered

Description: The rice rat, also known as the silver rice rat, is a small wetland rodent adapted to the island habitats of the Lower Florida Keys. This semi-aquatic rat depends upon both freshwater wetlands and saline wetland habitats. The rice rat can also be found among low lying mangrove transitional zones.

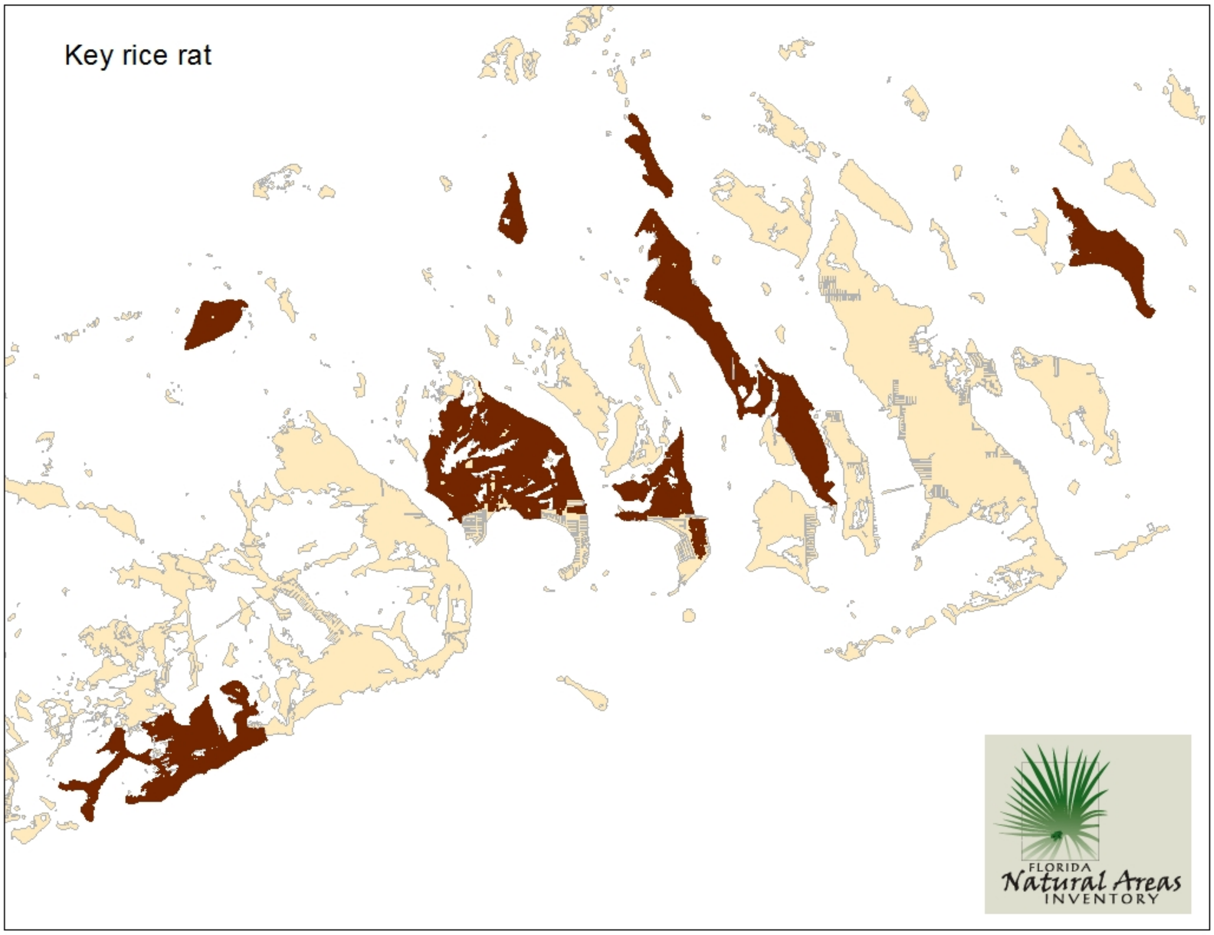


Figure 6.20 Known distribution of the silver rice rat. This map was provided by the Florida Natural Areas Inventory.

Map Comments:
None

Table 6.20 Known distribution of the silver rice rat. The contents of this table represent the information generated during workshop exercises. The contents of the first three rows are the recommendations of participants of Workshop 1, while the contents of row 4 are the priority actions determined by participants of Workshop 2.

Consequences of Sea Level Rise	• Sea level rise may initially be helpful due to mangrove use/expansion • Wins first as mangroves expand, but may ultimately lose in time as freshwater depletes • Will be pushed into black rat & cat habitat before they "win" • Can nest in mangroves but it may be difficult for them to entirely exist within that habitat • Vulnerable to changes in habitat – may be rate dependent/slow change may be ok, fast not ok o 1 ft. o 2 ft. o 3 ft. o 4 ft.
Proposed Adaptation Actions	• Wetland restoration to benefit rabbits would also benefit the rice rat • Information needed to find out what role black rats play and their interaction with rice rats
Trigger Points and Monitoring	• In absence of more knowledge, percent habitat lost is the best trigger point • Lots of monitoring/research needs to establish trigger points, life history, habitat needs/core habitat, and black rat interactions
Priority Actions	• Data gaps need to be filled • May benefit from marsh rabbit actions

APPENDIX 7. WS3 PINE ROCKLAND RESULTS

PINE ROCKLANDS AS A CASE STUDY

Conservation Status: Poor and declining. According to the State Wildlife Action Plan, 2,959 acres (1,197 ha) of Pine Rockland habitat exist (Figure 6.11), of which 77% (2,275 ac; 921 ha) are in existing conservation or managed areas. Another 13% (382 ac; 155 ha) are Florida Forever projects and 1% (25 ac; 10 ha) are SHCA-identified lands. The remaining 9% (277 ac; 112 ha) are other private lands.

Habitat Description: Pine Rockland is a unique type of pine flatwoods that is found exclusively on limestone substrate in the Florida Keys, the Big Cypress Swamp, and the Miami Rock Ridge (the limestone outcropping that rises from the Everglades to heights of 23 feet (7 m) above sea level). The overstory of Pine Rockland habitat contains a single canopy species, South Florida slash pine. The dominant pines tower over a savanna-like understory of saw palmettos, locust berry, willow bustic, beautyberry, broom grasses, silver palms, and a rich herbaceous layer. This community is often associated with rockland hammock and other short-hydroperiod freshwater wetland communities. These sub-tropical pine trees and understory plants have adapted to seasonal wildfires and the lack of soil on the exposed limestone rock. Pine Rockland communities are globally imperiled and support federal and state listed plant species, such as deltoid spurge and Small's milkwort which only occur in this habitat.

Climate Change Status: This habitat type is projected to experience severe declines due to SLR, with as much as 16,608 acres (~99% of the total for this habitat) projected to be lost with three meters of SLR. The noncumulative values for public and private lands (and both combined) for one and three meters of SLR are included in Table 1. However, it is likely that at least some of the projected loses of this habitat could migrate with SLR. Dead pine trees found within mangrove swamps in Key Largo were thought to be evidence of sea level rise (Alexander, 1974). This was confirmed decades later by through studying remaining pine rockland habitat, historic aerials and groundwater measurements. Pine mortality was found to proceed from the forest edge towards the interior, succeeding to vegetation better suited to new salinity regimes found in groundwater and soil salinity conditions (Ross et al. 1994).

Pine Rockland Rating 2.1

Participants were instructed to select their top three choices

Nr	Item	Selections
Pine rocklands - Adaptation Strategies (multiple selection) sorted by Sum Criterion "Prioritize adaptation strategies". 3 selections of 7 items. Ratings submitted: 20. Total selections 60. Abstentions not permitted. List of items randomized.		
1	Allow/assist transition of pine rocklands to tropical hardwood hammock (or some other community)	10
2	Create pine rockland community in new areas at minimal threat from SLR	10
3	Maintain current management (prescribed fire) as best possible until habitat is lost to sea level rise	10
4	Relocate pine rocklands species to pine flatwoods (or other suitable sites)	9
5	Evaluate alternative management actions to replace prescribed fire to maintain pine rocklands	8
6	Translocate pine rockland species to Caribbean pine rocklands (e.g. Bahamas), and focus species conservation efforts there	7
7	Increase elevation of pine rocklands through substrate addition to keep pace with SLR	6

2.2 Pine Rocklands Barriers – **This section shows all barriers identified by participants for the strategy: Increase elevation of pine rocklands through substrate addition to keep pace with sea level rise (SLR). All barriers are classified based upon the STAPLEE method. Numbers following comments only represent the order in which they were entered, and do not denote priority or importance.**

Social

- Who pays for the construction work? (#1)
- small scale and intense work so money might be better spent elsewhere (#6)
- if this is less attractive the public might resist it. (#7)
- what if people just don’t care about Pine Rockland? (#18)
- If we're raising the level of a natural area, we'd also have to raise the level of the surrounding land or else the site would be highly vulnerable to storm surge impacts and whatnot. So whether this strategy is viable will depend on broader social decisions about raising keys elevations. (#20)
- People/built environment will need limestone fill as well. Some may say, "Why are you fooling with the woods while our roads, homes, businesses are at risk?" (#22)
- People might resist a strategy that is so obviously managed, i.e. high in human intervention, on the grounds that it is no longer wild nature (#39)
- "You are changing my favorite place to recreate!" (#44)
- A lot of disturbance, equipment and intervention is not likely to be popular (#48)
- Likely visual impacts from dumping fill in forests. (#60)

Political

- Do constituents prefer other, more visible or higher impact activities? (#45)
- It’s not "sexy" (#50)

- Why are we spending dollars to keep a rockland elevated when we need $ to raise roads? (#51)
- Society may demand action for Pine Rockland through their legislative delegation (#54)
- People aren't likely to care that much (#55)
- This could be used as a political tool to suggest that money is being wasted and therefore the budget should be reduced or redirected (#59)
- If this habitat will continue to exist elsewhere, why preserve it at this location? (#63)
- Can you define any specific human benefits to gain more support? (#69)
- Economic and political cost (#71)
- Likely would engender opposition from those who think that if things are to be raised to protect them, they should be built environment to safeguard transportation and other structures. (#72)

Environmental

- In time, elevation of the rockland will eventually make it an island. (#3)
- Habitat and seed bank would be buried. Major collection and propagation efforts would be required. (#9)
- Understanding of behavior of freshwater lens under substrate additions. (#16)
- How do you minimize impacts to current habitat (#17)?
- The declining habitat may create issues with appropriate pollination, for persistent species survival and genetic isolation. (#19)
- All the different species (insect, etc.) that interact with the rocklands may not respond the same way to the elevation and the introduction of the substrate (#21)
- Damage to current plant and animal species (#23)
- Impacts material might have... unintended consequences (composition, other properties) (#27)
- Will it be affective in helping maintain the habitat (#32)?
- Are these sensitive to storm surges -- i.e., you raise the surface, but periodic storm inundation kills the area (#43)
- Can we capture other species with this strategy? (#46)
- Will other species be put at risk? (#49)
- Doing this may buy some time for some species, but eventually SLR will outpace it. What then becomes of what was created? Does it create a problem in the future marine environment that will long outlast any short-term benefit.? (#52)
- Apart from the issue of how to do this, where would clean fill come from and what would the environmental impacts be from the transport and placement of that fill. (#53)
- are ecological functions important to species retained with artificially building rocklands UP... up to 1 - 2 - 3 meters (#73)

Legal and Governance

- Are there FWS legal restrictions to adding fill? (#15)
- Would require modification of endangered species habitat and potentially cause "take" of listing species (including listed plants) (#28)
  - Any existing local, state or federal regulations that limit fill, such as ESA prohibitions (#33)
- In addition, refuge rules might prohibit or restrict fill (#58)
- Conflicting regulations among agencies (#66)

Technical

- The "original" substrate is more than just rubble. How do you recreate the drainage, characteristics of the limestone/substrate, etc.? (#8)
- finding substrate (#10)
- It won't work (#11)
- How do you not impact the current habitat? (#12)

- Getting the right type of substrate, equipment, etc. down to the Keys (#14)
  - Is this an economic question? (#25)
    - it's both, I think. A) the costs of bringing all the equipment d own there and B) do we even have the right equipment to do something like this? (#41)
- Questions about what type of substrate is "best", where to get it? (#26)
- can the function of added substrate functions and processes be maintained? - the limestone porous? h20 relationship? (#30)
- Where will you get the additional substrate from? Will the buildup of the substrate maintain the freshwater access? (#34)
- How would this even work? Adding rubble to forest to elevate is different then adding silt to marsh? (#37)
- Can you really raise the level of these parts of islands and keep them the way they were if you don't raise the level of the rest of the island? (#47)
- Has it been done before, and do we know how to do it? Are there success examples? (#62)
- We don't know how to do this yet. The freshwater contained within the limestone substratum is key to pine rockland ecosystem and the geology and geometry of the limestone will dictate the freshwater containment dynamic. (#65)

Administrative

- Will this affect other resources on FWS land? (#29)
- If this is the priority for some staff, is there time better spent on higher-impact activities? (#31)
- Will this require revising/amending guidance documents and policies? (#36)
- Will this require public and stakeholder engagement (#38)
- Who is responsible for raising the substrate? (#42)
- , (#57)
- Potential need to have actions approved by decision-makers in DC that are not inclined to devote resources to climate change (#68)
- Administrative flexibility to allow for this (#74)

Economic

- likely expensive for a short-term solution (#2)
- Very high cost for this adaptation strategy (#4)
- This sounds extremely costly and I would think human needs would be higher priority as SLR increases (#5)
- are there funds for this on a large scale? (#13)
- If this is funded for human benefit, are there ways to make this beneficial for wildlife? (#24)
- Engineering costs aside, collection and propagation would be costly. (#35)
- It could be costly if it needs to be done frequently (#40)
- Will this need to be done repeatedly with storms? (#56)
- maybe non-fws nwrs resources could be used which wouldn't result in competing $ for dealing with huge backlog of refuge maintenance in desperate need of $$$$ (#61)
- Sounds pretty darn expensive (#64)
- if we're not (seriously) talking about trying to raise the keys in general (b/c too expensive?) then it seems unlikely that society would be able/willing to pay to just raise the rocklands (#67)
- Limestone fill and moving it around costly. (#70)

Pine rocklands – Prioritization of barriers - **This section shows participants prioritization of barriers under the strategy: Increase elevation of pine rocklands**

through substrate addition to keep pace with sea level rise (SLR). Participants were instructed to vote for the most critical barriers to overcome.

Pine rocklands - Strategy 1 - Barriers (budget) sorted by Mean Resource: "Critical barriers". Total budget 5 for 15 items. Ratings submitted: 20. Total alloc. 100. Complete allocation required. List of items randomized.					
Nr	**Item**	**Mean**	**%**	**SD**	**ALOC**
1	All the different species (insect, etc.) that interact with the rocklands may not respond the same way to the elevation and the introduction of the substrate	0.70	14.00	0.23	9
2	Understanding of behavior of freshwater lens under substrate additions.	0.65	13.00	0.16	10
3	are ecological functions important to species retained with artificially building rocklands UP... up to 1 - 2 - 3 meters	0.50	10.00	0.15	7
4	How do you minimize impacts to current habitat	0.45	9.00	0.16	6
5	Will it actually be affective in helping maintain the habitat	0.40	8.00	0.10	8
6	Impacts material might have... unintended consequences (composition, other properties)	0.40	8.00	0.16	5
7	Damage to current plant and animal species	0.35	7.00	0.11	6
8	Apart from the issue of how to do this, where would clean fill come from and what would the environmental impacts be from the transport and placement of that fill.	0.30	6.00	0.09	6
9	Doing this may buy some time for some species, but eventually SLR will outpace it. What then becomes of what was created? Does it create a problem in the future marine environment that will long outlast any short-term benefit.?	0.30	6.00	0.09	6
10	Are these sensitive to storm surges -- i.e., you raise the surface, but periodic storm inundation kills the area	0.25	5.00	0.09	5
11	Will other species be put at risk?	0.25	5.00	0.09	5
12	Habitat and seed bank would be buried. Major collection and propagation efforts would be required.	0.25	5.00	0.11	4
13	Can we capture other species with this srategy?	0.10	2.00	0.06	2
14	In time, elevation of the rockland will eventually make it an island.	0.05	1.00	0.04	1
15	The declining habitat may create issues with appropriate pollination, for persistent species survival and genetic isolation.	0.05	1.00	0.04	1

APPENDIX 8. WS3 MIAMI BLUE BUTTERFLY RESULTS

MIAMI BLUE BUTTERFLY (*Cyclargus thomasi bethunebakeri)* **Federal Status:** Endangered

Description: The Miami blue butterfly is a small brightly colored butterfly, endemic only to South Florida. This species occupies tropical hardwood hammocks, pine rocklands, and beachside scrub, where it utilizes multiple hostplants; Including balloonvine (*Cardiospermum spp*.), gray nickerbean (*Caesalpinia bonduc*), and blackbead (*Pithecellobium spp.*). Miami blues can produce multiple generations each year between the months of February and November. Their eggs are laid on the flowers, flower buds, and terminal growth of its host plants. Up to seventeen ant species have been found to tend to larvae and may protect them from predators and parasitoids. This species was thought extinct until it was rediscovered in 1999 in Bahia Honda State Park in the Lower Florida Keys. Although subject to significant fluctuations, the Bahia Honda population persisted until 2010, when it disappeared. Fortunately, additional populations of Miami blues were discovered in Key West National Wildlife Refuge in 2006. Due to its small range and coastal proximity, the species would seem to be especially vulnerable to extinction from stochastic event and sea level rise.

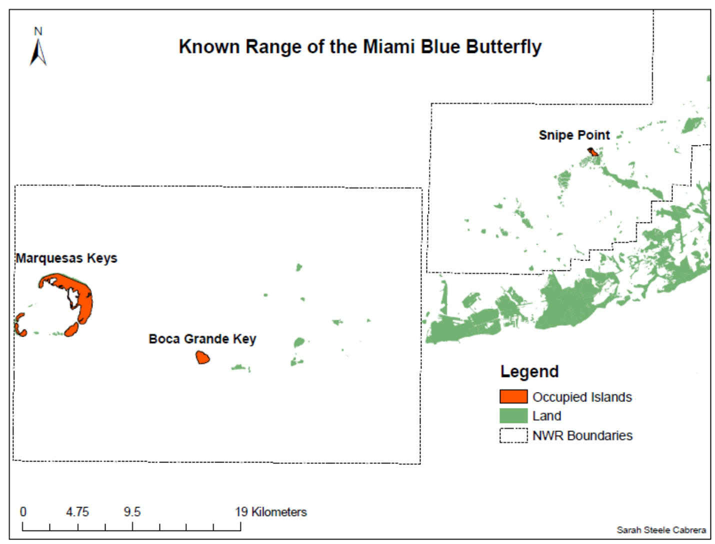


Figure 1. Known distribution of the Miami blue butterfly (orange). This map was produced by the Florida Museum of Natural History's McGuire Center for Lepidoptera & Biodiversity

Table 1. Miami blue butterfly results. The contents of this table represent the information generated during workshop exercises. The contents of the first three rows are the recommendations of species experts from Workshop 1, while the contents of row 4 are the priority actions determined by conservation practitioners in Workshop 2.

Consequences of Sea Level Rise	• Susceptible to stochastic events, like hurricanes
	• Role of erosion is critical. Habitat is likely 6 ft., but quality habitat will likely vanish before 6 ft. of sea level rise
	  o 1ft.
	  o 2 ft. upland habitat may still exist
	  o 3 ft. habitat will likely not exist
	  o 4 ft. alongside storms this sea level would be damaging to any remaining populations

Proposed Adaptation Actions	• Reintroductions have already begun and should continue • Reintroduction sites should be chosen to take sea level rise into account • Developing criteria for reintroduction site selection
Trigger Points and Monitoring	• Post-reintroduction monitoring of released individuals • At 1 ft. of sea level rise, prioritize reintroduction sites in the mainland
Manager's Priority Actions	• Within Keys: plant on high ground, no spraying where host plants exist, or could be • Host plants to be incorporated to restoration projects, development landscaping, and potentially private landscaping • Increase education and nursery availability for host plants • Increase populations to get off list, then extend range in Keys (potential sites: Lignum Vitae Key, Key Largo, Big Pine Key) • Future may be on the mainland

Ex-Situ Considerations	• Make host plants readily available and promote planting on private lands • Develop Species Survival Plan and move into Association of Zoos and Aquariums management • Assisted migration to new habitats outside historic range • Establish rooftop gardens where possible (i.e. large chain stores, government buildings, schools) with host plants and nectar plants

Table 2. Miami Blue Butterfly Rating

Participants were instructed to select their top three choices

Miami blue butterfly - Adaptation Strategies (multiple selection) sorted by Sum Criterion "Priority strategies". 3 selections of 10 items. Ratings submitted: 7. Total selections 21. Abstentions not permitted. List of items randomized.		
Nr	**Item**	**Selections**
1	Extend range of MBB in the Keys (Lignum Vitae Key, Key Largo, Big Pine Key)	4
2	Incorporate host plants into restoration projects and corporate and private landscaping	4
3	Continue reintroductions, include SLR into site selection criteria	3
4	Increase nursery availability of host plants	3
5	Assisted migration to new habitat outside historic range (south Florida)	2
6	Increase education, importance of host plant and potential impacts	2
7	Prohibit insecticide/herbicide spraying where host plants exist	2
8	Promote planting of host plants on private lands	1
9	Develop a Species Survival Plan, focus on captive populations, turn over management to Association of Zoos and Aquariums	0
10	Establish rooftop gardens with host and nectar plants	0

1.1 STRATEGY 1 RESULTS

Miami Blue Butterfly Barriers – This section shows all barriers identified by participants for three strategies related to the Miami blue butterfly. All barriers are classified based upon the STAPLEE method. Numbers following comments only represent the order in which they were entered, and do not denote priority or importance.

Strategy 1: Incorporate host plants into restoration projects and corporate and private landscaping

Environmental

- any negative impacts of host plants in areas beyond their native range? (#6)
- Simply planting host plants may not create effective habitat for the butterfly if there are other factors that are needed (#19)

- Stick within historical range of the host plant AND within places where the butterfly would be reintroduced and/or able to colonize (#23)
- Lack of major restoration projects within which to introduce host plants (#31)
- Most ecological restoration projects would have their own goals and may not which to incorporate this set of plants (#34)
- Are there hybridization issues with the plants (i.e., native plants that hybridize with non-natives reducing their ability to act as host plants)? (#36)

Economic

- Who pays for the propagation of the host plants and ants? (#1)
- Where are the host plants and ants propagated? Are there facilities and staff available now? (#3)
- are there subsidies/grants to help private landowners/corporations plant host plants? (#12)
- Are there existing policies that would prevent this strategy from being funded? (#27)
- Cultivating natives can be costly; who pays? (#28)
- Lack of public outreach (#40)

Legal and Governance

- Identifying conservation lands with willing managers (#7)
- Species management responsibilities on private lands (#13)
- are there ordinances restricting species of plants that can be added to landscapes in these proposed reintroduction areas? (#16)
- Host plant and exotic management (iguanas) on both public and private lands (#17)
- without equal guarantees issues related to critical habitat on private lands may limit landowner participation (#24)
- How do you make the plants available to the public? who regulates or tracks where these plant populations go? How do you evaluate the success of the plantings on private lands without physically observing butterflies using those plants, which would require access to those public lands? (#29)
- Are the restoration projects already scoped? Would requiring this derail existing projects? (#33)

Political

- Is there public support for this effort? How do you create a public awareness and acceptance that this effort is important? (#10)
- Are there existing policies that would prevent this strategy from being acceptable? (#25)
  - Some local govt have restrictions about what plants can be used in its jurisdiction (e.g. Sanibel island) (#30)
- Usual concerns about encouraging spread of federally listed species b/c of the legal obligations that accompany it. (#37)

Social

- who cares about this little butterfly? (public apathy towards conserving a non-charismatic species) (#2)
- Host plants may not be desirable for landscaping (aesthetically) (#4)
- Reluctance to provide habitat for an endangered species on private land that may limit what can be done on that land (#8)
  - this seems to cross over into legal/governance as well (#26)
- Would these plants be viewed as desirable landscaping plants? (#9)
- Private landowners may be wary of creating endangered species habitats for fear of regulatory limits on land use if butterflies colonized (#15)
  - yes! And relates to potential legal barrier (#21)

- Competing objective with pest control including mosquitos (#20)
- Butterflies are popular; where partnerships involved (e.g., corporate landscaping), this effort sustainable only if it garnered success (i.e., establishment of the butterfly) soon (#32)
  - This is a possible non-barrier- butterfly gardens are popular (#35)

Technical

- Can these host plants be cultivated effectively at scale? (#5)
- What soil conditions are needed and are they conducive to corporate and private landscapes? (#11)
- Host plants may not be the only factor needed for the species (#14)
- How do you encourage landscape planners to incorporate these plants into their plans? Are these plants and their associated species interdependent? Are they attractive? (#18)
- are there predators found in these reintroduction areas that might inhibit successful reintroduction? (i.e. iguanas) (#22)
- What is the source of the host plants? (#38)
- Technical know-how may be lacking for successful cultivation of these plants (#39)

Miami Blue Butterfly - Prioritization of barriers - **This section shows participants prioritization of barriers under** Strategy 1: Incorporate host plants into restoration projects and corporate and private landscaping . **Participants were instructed to vote for the most critical barriers to overcome.**

Miami blue butterfly - Strategy 1 - Across (top) Barriers (budget) sorted by Mean Resource: "Critical barriers". Total budget 10 for 36 items. Ratings submitted: 8. Total alloc. 80. Complete allocation required. List of items randomized.					
Nr	**Item**	**Mean**	**%**	**SD**	**ALOC**
1	Private landowners may be wary of creating endangered species habitats for fear of regulatory limits on land use if butterflies colonized	1.13	11.25	0.09	6
2	How do you encourage landscape planners to incorporate these plants into their plans? Are these plants and their associated species interdependent? Are they attractive?	0.88	8.75	0.08	5
3	Simply planting host plants may not create effective habitat for the butterfly if there are other factors that are needed	0.63	6.25	0.10	3
4	Can these host plants be cultivated effectively at scale?	0.50	5.00	0.07	3
5	Host plants may not be the only factor needed for the species	0.50	5.00	0.07	3
6	Are there existing policies that would prevent this strategy from being funded?	0.50	5.00	0.10	2
7	Usual concerns about encouraging spread of federally listed species b/c of the legal obligations that accompany it.	0.50	5.00	0.10	2

Miami blue butterfly - Strategy 1 - Across (top) Barriers (budget) sorted by Mean Resource: "Critical barriers". Total budget 10 for 36 items. Ratings submitted: 8. Total alloc. 80. Complete allocation required. List of items randomized.					
Nr	**Item**	**Mean**	**%**	**SD**	**ALOC**
8	are there ordinances restricting species of plants that can be added to landscapes in these proposed reintroduction areas?	0.38	3.75	0.05	3
9	Competing objective with pest control including mosquitos	0.38	3.75	0.05	3
10	Technical know-how may be lacking for successful cultivation of these plants	0.38	3.75	0.05	3
11	who cares about this little butterfly? (public apathy towards conserving a non-charismatic species)	0.38	3.75	0.05	3
12	How do you make the plants available to the public? who regulates or tracks where these plant populations go? How do you evaluate the success of the plantings on private lands without physically observing butterflies using those plants, which would require access to those public lands?	0.38	3.75	0.07	2
13	Stick within historical range of the host plant AND within places where the butterfly would be reintroduced and/or able to colonize	0.38	3.75	0.07	2
14	Lack of major restoration projects within which to introduce host plants	0.38	3.75	0.10	1
15	Reluctance to provide habitat for an endangered species on private land that may limit what can be done on that land	0.25	2.50	0.04	2
16	Where are the host plants and ants propagated? Are there facilities and staff available now?	0.25	2.50	0.04	2
17	Who pays for the propagation of the host plants and ants?	0.25	2.50	0.04	2
18	Would these plants be viewed as desirable landscaping plants?	0.25	2.50	0.04	2
19	any negative impacts of host plants in areas beyond their native range?	0.25	2.50	0.07	1
20	Butterflies are popular; where partnerships involved (e.g., corporate landscaping), this effort sustainable only if it garnered success (i.e., establishment of the butterfly) soon	0.25	2.50	0.07	1
21	Host plant and exotic management (iguanas) on both public and private lands	0.25	2.50	0.07	1
22	Lack of public outreach	0.25	2.50	0.07	1
23	are there subsidies/grants to help private landowners/corporations plant host plants?	0.13	1.25	0.03	1
24	Identifying conservation lands with willing managers	0.13	1.25	0.03	1

Miami blue butterfly - Strategy 1 - Across (top) Barriers (budget) sorted by Mean Resource: "Critical barriers". Total budget 10 for 36 items. Ratings submitted: 8. Total alloc. 80. Complete allocation required. List of items randomized.					
Nr	**Item**	**Mean**	**%**	**SD**	**ALOC**
25	without equal guarantees issues related to critical habitat on private lands may limit landowner participation	0.13	1.25	0.03	1
26	Most ecological restoration projects would have their own goals and may not which to incorporate this set of plants	0.13	1.25	0.03	1
27	Species management responsibilities on private lands	0.13	1.25	0.03	1
28	What soil conditions are needed and are they conducive to corporate and private landscapes?	0.13	1.25	0.03	1
29	Are there existing policies that would prevent this strategy from being acceptable?	0.00	0.00	0.00	0
30	Are there hybridization issues with the plants (i.e., native plants that hybridize with non-natives reducing their ability to act as host plants)?	0.00	0.00	0.00	0
31	are there predators found in these reintroduction areas that might inhibit successful reintroduction? (i.e. iguanas)	0.00	0.00	0.00	0
32	Are the restoration projects already scoped? Would requiring this derail existing projects?	0.00	0.00	0.00	0
33	Cultivating natives can be costly; who pays?	0.00	0.00	0.00	0
34	Host plants may not be desirable for landscaping (aesthetically)	0.00	0.00	0.00	0
35	Is there public support for this effort? How do you create a public awareness and acceptance that this effort is important?	0.00	0.00	0.00	0
36	What is the source of the host plants?	0.00	0.00	0.00	0

Miami Blue Butterfly Barrier Solutions

Strategy 1: Identify potential solutions for each barrier to implementation of this strategy for the Miami blue butterfly.

Private landowners may be wary of creating endangered species habitats for fear of regulatory limits on land use if butterflies colonized

- Safe Harbor agreements (#1)
- Create sufficiently broad and flexible safe harbor agreements to alleviate property owner concerns (#2)
- Inform public about Safe Harbor Agreements and potentially draft an island wide example to share at open houses (#3)
- Launch public awareness campaign to raise regional profile of Miami blue -- elevate it to regional icon status (#9)

- Develop incentive program that financially rewards any landowner with Miami blues on their property. Turn from disincentive into incentive. (#10)
  - in addition to financial incentives, offer signage (like the native landscape plaques/signs) to create a social norm for promoting this species (#19)
- Fly black helicopters over private landowners' property and distribute state media detailing the UN (#12)
- Find and cultivate community champions to help elevate value of species preservation (Butterfly world, Gardening clubs, college environmental clubs, other NGOs) (#14)
- Work with county/city parks departments to create demonstration habitats (#25)

How do you encourage landscape planners to incorporate these plants into their plans? Are these plants and their associated species interdependent? Are they attractive?

- Look toward local landscape requirement codes to include the desired plant pallet (#4)
- Create customer demand through a public campaign (#5)
  - HGTV shows, social media, etc. (#6)
- Work with county or local governments to incentivize landowners to plant these host plants (#7)
- Work with UF-IFAS and County extensions to encourage planting in butterfly gardens (#8)
- Talk to master gardener clubs about how they would incorporate these host plants into butterfly garden designs then make those plans available to the public. (#16)
- Provide economic incentives. $$$$ (#18)
- Work with Florida DOT to incorporate into highway landscaping pallet if possible (#20)
- Develop best practice guides for cultivation and maintenance of these host plants, including site selection criteria (#21)
- Work with local nurseries to increase availability of host plants, Market as butterfly attractants (possibly iguana attractants as well) (#22)
- Encourage local schools to raise the plants and plant them in school areas, then monitor those efforts through time. (#23)
- Demonstrate and publicize success by focusing efforts where the butterfly would be introduced or could migrate from existing population. (#24)

Host plants may not be the only factor needed for the species

- Research host plants and their dynamics to better understand the life cycle of the butterfly so that new habitats may be created and shared with landscape architects (#11)
- Research to identify other factors needed. If there is something that is uniquely tied to the host plant (soils, ants, etc.), work with nurseries to include those things in the propagation and distribution methods (#13)
- Endless research followed up with recommendations of more research (#15)
- Research into role of other threats (pesticides, invasive) as limiting factors (#17)

1.2 STRATEGY 2 RESULTS

Miami Blue Butterfly Barriers – This section shows all barriers identified by participants for three strategies related to the Miami blue butterfly. All barriers are classified based upon the STAPLEE method. Numbers following comments only represent the order in which they were entered, and do not denote priority or importance.

Strategy 2 - **Expand reintroductions across historic range, include SLR into site selection criteria.**

Environmental

- Concern about the effect of introducing this species on other native butterflies now in those systems (#5)
  - What time frame do we evaluate to consider a population to be successfully re-introduced? Do we use population levels or presence/absence? (#46)
- will predator species inhibit the success of reintroductions? (#24)
- how will host plant/habitat creation be integrated with reintroductions? (#32)
- Competition with other species that may be more adapted to changing climatic conditions (#36)
- Competing/ conflicting use of the land for other conservation species (#41)

Economic

- Scale of the potential reintroductions (#9)
  - Do we have a good idea - for a candidate new site - what all the reintroduction actions would cost? (#38)
- Is there funding for breeding and reintroduction programs? (#13)
- Cost of not only doing reintroduction but long-term maintenance of habitat and introduced populations (#15)
- Expanded monitoring costs (#42)
- Potential for reintroduced colonies to limit (or create perception of doing so) economic activities (#47)

Legal and Governance

- Legal problems with introducing a federally listed species onto private lands (#11)
- Are we able to manage the habitat (e.g., prescribed fire or simulation thereof) in new sites? (If not, the site isn't really a candidate) (#12)
- Local, state ordinances with unapproved removals or planting (#14)
- Mosquito spraying issues within all different municipalities (#22)
- Who will oversee management responsibilities? (#40)
- Are there existing frameworks that allow collaborations across agency and governmental jurisdictions? (#43)
- Given the historic range, a whole new set of stakeholders will be involved (county, city, landowners, etc.) (#45)
- What thresholds do we use to determine if we are being successful? (#49)
- Given the annual generation cycle, what timeline do we determine if we are being successful? When do we claim victory or walk away? (#50)

Political

- Competing objectives with other conservation priorities in proposed reintroduction sites (#18)
  - not just conservation priorities. Will be many competing priorities among land use (recreation, conservation, water management, etc.) (#28)
- Do current policies allow expand introductions? (#26)
  - this is more related to legal and governance, but I think the tie in is creating political will to CHANGE policies if needed, to allow reintroductions (#34)

Social

- Public Acceptance of introducing new habitats and stigma of T&E species (#1)
- again- public apathy about a non-charismatic species. people might want resources to be used elsewhere (#3)
- Should we destroy functioning habitats to the detriment of those species to benefit the butterfly and its hosts? (#6)

- For efforts to restore within historical range but far from recently/currently occupied areas, might there be social resistance to the idea that the species really did occur there (and therefore 'belongs')? (#20)
- Local community concerns about introducing a listed species in their area, and possible land use/land rights consequences (#33)
- Conservation community resistance to conducting "assisted migration". Even though historic range is extensive, South Florida may be viewed by some as outside of "recent" range. (#37)
- Lack of broad community recognition of this species as iconic and desirable (#44)

Technical

- Do we know enough about soils to re-create these habitats? (#2)
- Track record of current introductions (#4)
- We talked about the lack of success with wild breeding vs captive breeding- can we get them to successfully breed in the new areas? (#7)
- Have the factors that caused extirpation been removed? (#8)
- Given coastal proximity of historic range, will there be suitable options given SLR? (#10)
- Management of ecosystem components to ensure success (host plants, exotics, ants) (#16)
- How many butterflies can be captive breed and used for source material? (#17)
- Can suitable habitat really be created in sites now far afield from current populations? (#19)
- Can we continue the propagation of butterflies without causing genetic issues? (#21)
- Will considering SLR eliminate too many locations in the Keys to consider reintroduction? (#23)
- Does storm surge on higher elevation Keys create problems with periodic inundation? How does storm surge affect the host plants? (#25)
- Do we know enough about the suitable habitat to re-create the habitat in new areas that are above projected SLR (#27)?
- Lack of understanding about why the populations are not thriving in existing populations. If we don't know who to grow them there, how would we grow them elsewhere? (#29)
- Are the host plants dependent on surface waters or do they have deep tap roots? How would freshwater lens contraction affect them? (#30)
- For sites far from currently occupied areas, do we just need to add the host plant, the bug, and whatever ongoing management the host plant needs, or are there other (new) barriers? (#31)
- Have we studied the freshwater lens of other potential expansion sites, so we understand the best potential areas for habitat creation? (#35)
- Do we encourage building migration corridors (e.g., try to focus reintroductions on adjacent islands)? (#39)
- Timescale really matters here - work in places that might disappear due to sea-level rise soon (next few decades) really can only be justified as buying time for longer-term solutions, so those longer-term solutions need to be articulated and accepted alongside this type of short-term action. (#48)

Miami Blue Butterfly - Prioritization of barriers - **This section shows participants prioritization of barriers under** Strategy 2: Expand reintroductions across historic range, include SLR into site selection criteria. **Participants were instructed to vote for the most critical barriers to overcome.**

Miami blue butterfly - Strategy 2 - Across (top) Barriers (budget) sorted by Mean Resource: "Critical barriers". Total budget 15 for 46 items. Ratings submitted: 7. Total alloc. 105. Complete allocation required. List of items randomized.					
Nr	**Item**	**Mean**	**%**	**SD**	**ALOC**
1	Lack of understanding about why the populations are not thriving in existing populations. If we don't know who to grow them there, how would we grow them elsewhere?	1.29	8.57	0.08	5
2	Do we know enough about the suitable habitat to re-create the habitat in new areas that are above projected SLR	1.14	7.62	0.10	3
3	Have the factors that caused extirpation been removed?	1.00	6.67	0.07	4
4	Public Acceptance of introducing new habitats and stigma of T&E species	1.00	6.67	0.09	3
5	Cost of not only doing reintroduction but long-term maintenance of habitat and introduced populations	0.86	5.71	0.07	3
6	Track record of current introductions	0.86	5.71	0.14	1
7	Is there funding for breeding and reintroduction programs?	0.71	4.76	0.07	3
8	Given the historic range, a whole new set of stakeholders will be involved (county, city, landowners, etc.)	0.57	3.81	0.05	3
9	We talked about the lack of success with wild breeding vs captive breeding- can we get them to successfully breed in the new areas?	0.57	3.81	0.07	2
10	Do current policies allow expand introductions?	0.43	2.86	0.05	2
11	How many butterflies can be captive breed and used for source material?	0.43	2.86	0.05	2
12	Should we destroy functioning habitats to the detriment of those species to benefit the butterfly and its hosts?	0.43	2.86	0.05	2
13	Concern about the effect of introducing this species on other native butterflies now in those systems	0.43	2.86	0.07	1
14	Are the host plants dependent on surface waters or do they have deep tap roots? How would freshwater lens contraction affect them?	0.29	1.90	0.03	2
15	Can suitable habitat really be created in sites now far afield from current populations?	0.29	1.90	0.03	2
16	Competing/ conflicting use of the land for other conservation species	0.29	1.90	0.03	2
17	Competing objectives with other conservation priorities in proposed reintroduction sites	0.29	1.90	0.03	2
18	Conservation community resistance to conducting "assisted migration". Even though historic range is extensive, South Florida may be viewed by some as outside of "recent" range.	0.29	1.90	0.03	2
19	Do we know enough about soils to re-create these habitats?	0.29	1.90	0.03	2

Miami blue butterfly - Strategy 2 - Across (top) Barriers (budget) sorted by Mean Resource: "Critical barriers". Total budget 15 for 46 items. Ratings submitted: 7. Total alloc. 105. Complete allocation required. List of items randomized.					
Nr	Item	Mean	%	SD	ALOC
20	Given the annual generation cycle, what timeline do we determine if we are being successful? When do we claim victory or walk away?	0.29	1.90	0.03	2
21	again- public apathy about a non-charismatic species. people might want resources to be used elsewhere	0.29	1.90	0.05	1
22	Can we continue the propagation of butterflies without causing genetic issues?	0.29	1.90	0.05	1
23	Competition with other species that may be more adapted to changing climatic conditions	0.29	1.90	0.05	1
24	Given coastal proximity of historic range, will there be suitable options given SLR?	0.29	1.90	0.05	1
25	Lack of broad community recognition of this species as iconic and desirable	0.29	1.90	0.05	1
26	Will considering SLR eliminate too many locations in the Keys to consider reintroduction?	0.29	1.90	0.05	1
27	Are there existing frameworks that allow collaborations across agency and governmental jurisdictions?	0.14	0.95	0.02	1
28	Are we able to manage the habitat (e.g., prescribed fire or simulation thereof) in new sites? (If not, the site isn't really a candidate)	0.14	0.95	0.02	1
29	Does storm surge on higher elevation Keys create problems with periodic inundation? How does storm surge affect the host plants?	0.14	0.95	0.02	1
30	Do we encourage building migration corridors (e.g., try to focus reintroductions on adjacent islands)?	0.14	0.95	0.02	1
31	Expanded monitoring costs	0.14	0.95	0.02	1
32	Have we studied the freshwater lens of other potential expansion sites, so we understand the best potential areas for habitat creation?	0.14	0.95	0.02	1
33	how will host plant/habitat creation be integrated with reintroductions?	0.14	0.95	0.02	1
34	Local community concerns about introducing a listed species in their area, and possible land use/land rights consequences	0.14	0.95	0.02	1
35	Mosquito spraying issues within all different municipalities	0.14	0.95	0.02	1
36	Timescale really matters here - work in places that might disappear due to sea-level rise soon (next few decades) really can only be justified as buying time for longer-term solutions, so those longer-term solutions need to be articulated and accepted alongside this type of short-term action.	0.14	0.95	0.02	1

Miami blue butterfly - Strategy 2 - Across (top) Barriers (budget) sorted by Mean Resource: "Critical barriers". Total budget 15 for 46 items. Ratings submitted: 7. Total alloc. 105. Complete allocation required. List of items randomized.					
Nr	**Item**	**Mean**	**%**	**SD**	**ALOC**
37	What thresholds do we use to determine if we are being successful?	0.14	0.95	0.02	1
38	For efforts to restore within historical range but far from recently/currently occupied areas, might there be social resistance to the idea that the species really did occur there (and therefore 'belongs')?	0.00	0.00	0.00	0
39	For sites far from currently occupied areas, do we just need to add the host plant, the bug, and whatever ongoing management the host plant needs, or are there other (new) barriers?	0.00	0.00	0.00	0
40	Legal problems with introducing a federally listed species onto private lands	0.00	0.00	0.00	0
41	Local, state ordinances with unapproved removals or planting	0.00	0.00	0.00	0
42	Management of ecosystem components to ensure success (host plants, exotics, ants)	0.00	0.00	0.00	0
43	Potential for reintroduced colonies to limit (or create perception of doing so) economic activities	0.00	0.00	0.00	0
44	Scale of the potential reintroductions	0.00	0.00	0.00	0
45	Who will oversee management responsibilities?	0.00	0.00	0.00	0
46	will predator species inhibit the success of reintroductions?	0.00	0.00	0.00	0

Miami Blue Butterfly Barrier Solutions

Strategy 2: Identify potential solutions for each barrier to implementation of this strategy for the Miami blue butterfly.

Do we know enough about the suitable habitat to re-create the habitat in new areas that are above projected SLR?

- research life history characteristics (#1)
- Quick and easy habitat suitability models (#2)
- Compile all knowledge on life history needs and identify any potential knowledge gaps. Fill those gaps with existing data on similar species use and apply those principles to new habitats and monitor introduced butterfly use. (#7)
- Identify, create, and implement a few pilot sites to start (#12)
- Research to understand the historical "climate space" of the butterfly. Has climate change has already 'moved' the keys outside of the butterfly's climate space? Are more northerly parts of the species' historical range more climatically suitable for the species today? (#13)
  - Based on climate-space research, identify sites that are suitable from an SLR perspective (#17)

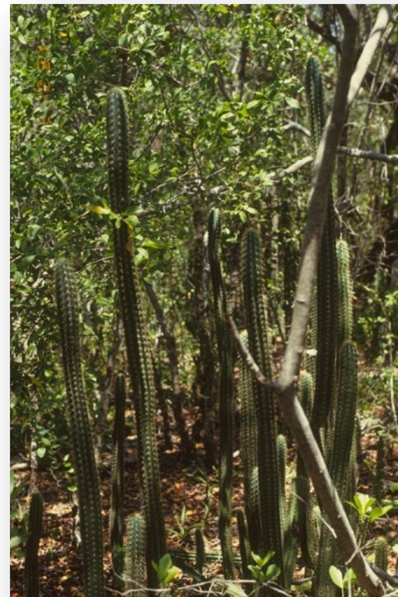
- Conduct small-scale soft reintroductions in controlled conditions to determine local habitat/climate suitability (#16)
- $$$$$$ (#20)
- Determine non-habitat threats/constraints, including pesticides, invasive, etc. (#23)

Cost of not only doing reintroduction but long-term maintenance of habitat and introduced populations

- Save our butterfly Kickstarter :) (#3)
- Develop partnerships to add capacity (utilize volunteers, city/ county govts, garden clubs, etc.) (#4)
- Corporate sponsorship (#5)
  - or local businesses (#8)
  - or NGOs/private citizens (#10)
- Create an initiative that has buy-in from large donors. (#6)
- Develop realistic cost estimates for program to serve as basis for marketing it and raising needed funds (#9)
- Business plan for the species that quantifies cost and outlines success measures that can be adopted by agencies and NGO's/philanthropists (#11)
- Establish maintenance and monitoring funding for a set timeframe (contemplate sub set to monitor). Continually refund only if areas meet established metrics for success. (#14)
- Link the effort to save the butterfly to other species to increase public awareness of this butterfly. (#15)
- Lobby congress to pass the "Recovering Americas Wildlife Act" (#18)
- Butterfly license plate (#19)
- Reach out to schools to encourage biology teachers to have students conduct monitoring on test plots. Also, could utilize interested publics in a simple monitoring regimen. (#21)
- Investigate low-cost options for long-term maintenance - for example, Karner blue success stems from encouraging forestry activities generally (disturbance that the species likes) but discouraging certain activities during a short breeding season window). (#22)

APPENDIX 9. WS3 KEYS TREE CACTUS

Key tree-cactus *(Pilosocereus robinii)* **Federal Status:** Endangered



Description: The Key tree-cactus is a large cactus with columnar stems, that can reach up to 10 meters in height. It produces white flowers, which are followed by purplish-red fruits when pollinated. The tree cactus is endemic to the upper Florida Keys, where it occurs within tropical hardwood hammocks, and transitional woodland habitats, often referred to as cactus hammocks. This species can be confused with the related *P. polygonus*, leading to a potential overestimation of remaining populations. Active efforts are in place to reintroduce the tree cactus to areas it once occurred within the upper keys. However, recent outplanting efforts for the tree cactus have been lost to salt water intrusion. There is a reintroduced population in Windley Key State Park and Crocodile Lake National Wildlife Refuge, with some individuals planted over 2m above sea level. A Large ex situ collection of live plants at Fairchild Botanical Gardens in Miami, along with many seeds. There are presently only 6 known populations in the wild. These wild populations will see impacts to 2 of the 6 populations at 1 foot of sea level rise. With each interval of sea level rise more populations will see impacts, and full extinction is likely by 4ft of sea level rise, or sooner without intervention.

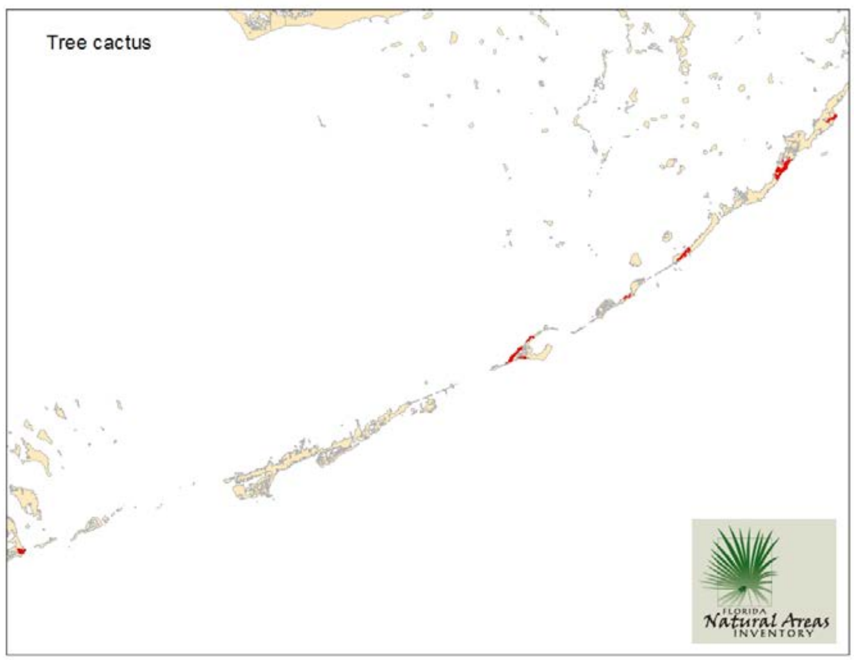


Figure 1. Known range of Keys tree cactus (red). This map was produced by the Florida Natural Areas Inventory.

Table 1. Keys tree cactus results. The contents of this table represent the information generated during workshop exercises. The contents of the first three rows are the recommendations of species experts from Workshop 1, while the contents of row 4 are the priority actions determined by conservation practitioners in Workshop 2.

Consequences of Sea Level Rise	• Only 6 populations present in the wild o 1 ft. populations on Pennekamp will be affected (quality of plants affected negatively) as well as populations on Big Pine Key. Nuisance flooding events, salt water stress o 2 ft. Long Key pop on Golden Orb Trail affected, sea level rise will cause salt water laterally moving in, pushing vegetation back. Lower & upper Matecumbe stressed. Big Pine Key population highly stressed. o 3 ft. Big Pine Key will be extirpated. Long Key highly stressed, possibly extirpated. Some for lower/upper Matecumbe. o 4 ft. Big Pine Key extirpated, Long Key likely mortality, lower/upper Matecumbe likely extirpated.
Proposed Adaptation Actions	• Currently seed collection is under way. Continue these efforts • Suggest continual reintroduction at higher elevations • Augmentation of all existing populations already ongoing, suggested continuation • On Big Pine Key, collect germ plasm and introduce to Upper Big Pine Key
Trigger Points, Monitoring, and Research Needs	• Population monitoring on a quarterly basis • Salinity tolerance testing complete, incorporate into decisions • Research needed on dispersal, pollinators, seed storage/germination (viability), and genetics to make decisions on intensity or need of collection/translocation • Research the impact of relocation now, and based on the outcome relocate to mainland at 50% loss
Manager's Priority Actions	Now • Continue outplanting and restoration efforts • Explore concept of planting on private lands • Monitor groundwater salinity and utilize tolerance data for trigger points Trigger – 50% population reduction • Consider ex-situ actions

Ex-Situ Considerations	• Make available to private landowners for landscaping in the Florida Keys • Expand botanical garden collections • Assisted migration to managed lands in South Florida • Develop green roof cactus hammock ecosystem

Table 2. Keys Tree Cactus Rating

Participants were instructed to select their top three choices

Keys tree cactus - Adaptation Strategies (multiple selection) sorted by Sum Criterion "Prioritize adaptation strategies". 3 selections of 9 items. Ratings submitted: 7. Total selections 21. Abstentions not permitted. List of items randomized.		
Nr	**Item**	**Selections**
1	Expand botanical garden collections (increase size of current collections and add stock to new collections/locations)	5
2	Reintroduction at higher elevations, within known range	4
3	Assisted migration to managed lands in South Florida (outside of historical range)	3
4	Continue augmentation of existing populations, focusing on populations at higher elevations	3
5	Develop green roof cactus hammock ecosystem	3
6	Make stock publicly available to anyone to plant wherever they choose.	2
7	Collect germ plasm on Big Pine Key and introduce to Upper Big Pine Key	1
8	Continue seed collection, focus on saving genetic stock until future conditions are suitable for re-introduction	0
9	Plant on targeted private lands (work with selected property owners)	0

4.1 STRATEGY 1 RESULTS

Florida Keys Tree Cactus Barriers – This section shows all barriers identified by participants for three strategies related to the Florida Keys tree cactus. All barriers are classified based upon the STAPLEE method. Numbers following comments only represent the order in which they were entered, and do not denote priority or importance.

Strategy 1: Assisted migration to managed lands in South Florida (outside of historical range)

Social

- Public and stakeholder concern about introduction of species outside of historical range (#1)
  - Lots of adaptation of the social system and built environment will be needed too. Perception of wasting money/effort on obscure species may be a problem. (#23)
- Aversion to "new" species, even if they are not invasive (#2)
- Will it still be the "Keys tree cactus"? (#20)
- Actively saying we are ok with moving species may result in the public thinking they should do the same in a less informed way (#21)

Technical

- We need to figure out where they would thrive (e.g., appropriate microclimate, soils, hydrology...) (#3)
  - We could say that they may not take to just anywhere. May be constrained on site selection (#16)
- Would we set boundaries on how far species can be moved long-term? (#26)

Administrative

- Authority to move species (#6)
- Willingness of managers within historic range to donate plant material (#9)
- Moving listed species may be a hassle administratively even if it's not precluded regulatorily (#10)
- Willingness of managers outside of historic range to accept new species (#11)
- Administrative bottleneck within FWS - decision would likely be made in DC (#13)

Political

- Jurisdictional issues if species are planted on state vs. federally owned lands, private lands (#19)
- Political angling over "rights" to rename the species (#24)
- Support or resistance from local, state, federal elected officials (#28)

Legal and Governance

- If ESA section 10J permit required, need to show the species current habitat is irreversibly altered or destroyed per FWS regulations (#4)
- Laws at target site might prohibit or restrict introduction of nonnative species (#7)
- Legal protections of introduced population will be less than "naturally occurring" population (#22)
- Support or resistance from local, state, federal elected officials (#25)

Economic

- May be costly if the species need extra management before they get established in new areas (#8)
- Introduction and continued management to ensure persistence raise costs (#15)
- No current funding for mainland surveys, introductions, monitoring, etc. (#17)
- Cost probably wouldn't be very high, but it would need to be sustained to ensure successful establishment, growth, reproduction, and response to perturbations. Funding needs to long term. (#18)

Environmental

- Potential impacts/interactions with new systems has not been examined. (#5)
- New soil types may not support species. (#12)
- Potential for new areas to not be fully suitable due to a variety of ecological factors (e.g., subtle differences in soils, plant/animal interactions, etc.) (#14)
- Will introduction detrimentally affect target location (#27)?

Keys Tree Cactus - Prioritization of barriers - **This section shows participants prioritization of barriers under** Strategy 1: Assisted migration to managed lands in South Florida (outside of historical range). **Participants were instructed to vote for the most critical barriers to overcome.**

Keys tree cactus - Strategy 1 - Across (top) Barriers (budget) sorted by Mean Resource: "Critical barriers". Total budget 8 for 26 items. Ratings submitted: 6. Total alloc. 48. Complete allocation required. List of items randomized.					
Nr	**Item**	**Mean**	**%**	**SD**	**ALOC**
1	If ESA section 10J permit required, need to show the species current habitat is irreversibly altered or destroyed per FWS regulations	0.83	10.42	0.13	3
2	Potential for new areas to not be fully suitable due to a variety of ecological factors (e.g., subtle differences in soils, plant/animal interactions, etc.)	0.67	8.33	0.06	4
3	Willingness of managers outside of historic range to accept new species	0.67	8.33	0.09	3
4	Actively saying we are ok with moving species may result in the public thinking they should do the same in a less informed way	0.50	6.25	0.06	3
5	Cost probably wouldn't be very high, but it would need to be sustained to ensure successful establishment, growth, reproduction, and response to perturbations. Funding needs to long term.	0.50	6.25	0.06	3
6	Potential impacts/interactions with new systems has not been examined.	0.50	6.25	0.06	3
7	Authority to move species	0.50	6.25	0.10	2
8	Laws at target site might prohibit or restrict introduction of nonnative species	0.50	6.25	0.10	2
9	No current funding for mainland surveys, introductions, monitoring, etc.	0.33	4.17	0.06	2
10	Public and stakeholder concern about introduction of species outside of historical range	0.33	4.17	0.06	2
11	Support or resistance from local, state, federal elected officials	0.33	4.17	0.06	2
12	Support or resistance from local, state, federal elected officials	0.33	4.17	0.06	2
13	Will introduction detrimentally affect target location	0.33	4.17	0.06	2
14	Will it still be the "Keys tree cactus"?	0.33	4.17	0.06	2
15	Would we set boundaries on how far species can be moved long-term?	0.33	4.17	0.09	1
16	Administrative bottleneck within FWS - decision would likely be made in DC	0.17	2.08	0.05	1
17	Introduction and continued management to ensure persistence raise costs	0.17	2.08	0.05	1
18	Jurisdictional issues if species are planted on state vs. federally owned lands, private lands	0.17	2.08	0.05	1
19	Legal protections of introduced population will be less than "naturally occurring" population	0.17	2.08	0.05	1
20	Moving listed species may be a hassle administratively even if it's not precluded regulatorily	0.17	2.08	0.05	1

Keys tree cactus - Strategy 1 - Across (top) Barriers (budget) sorted by Mean Resource: "Critical barriers". Total budget 8 for 26 items. Ratings submitted: 6. Total alloc. 48. Complete allocation required. List of items randomized.					
Nr	Item	Mean	%	SD	ALOC
21	We need to figure out where they would thrive (e.g., appropriate microclimate, soils, hydrology...)	0.17	2.08	0.05	1
22	Aversion to "new" species, even if they are not invasive	0.00	0.00	0.00	0
23	May be costly if the species need extra management before they get established in new areas	0.00	0.00	0.00	0
24	New soil types may not support species.	0.00	0.00	0.00	0
25	Political angling over "rights" to rename the species	0.00	0.00	0.00	0
26	Willingness of managers within historic range to donate plant material	0.00	0.00	0.00	0

3.2 Keys Tree Cactus Barrier Solutions

Strategy 1: Assisted migration to managed lands in South Florida (outside of historical range)

If ESA section 10J permit required, need to show the species current habitat is irreversibly altered or destroyed per FWS regulations

- Determine if there is a legal barrier in ESA for this plant (#1)
- determine which regs apply in the first place (#2)
- Understanding of the definition of "irreversibly altered..." (#3)
- Bypass the Feds via state authority (#4)
- Applies to plants? (#5)
- Work with legislators to revise regulations (if necessary), and generate grassroots and grasstops campaign to build support (#6)
- Comply with state endangered or invasive restrictions on movement (#7)
- change regs if necessary. Would this be a matter of a small internal tweak or do we really need to grapple with "the need for native habitat to be irreversibly altered or destroyed" (#8)

Willingness of managers outside of historic range to accept new species

- Higher bureaucrat dictating that this will be done (#9)
- Change managers (#10)
- Locate elsewhere (#11)
- Bring scientists and managers together to discuss potential pluses and minuses, come to agreement (#12)
- Incentivization of acceptance via additional funding for other projects (#13)
- Potential for additional funding sources to come in as new species comes in (#14)
- Develop working group of various stakeholders, land managers, etc., to discuss current administrative restrictions (#15)
- Build support among key stakeholders to apply pressure to managers (#16)
- "Re-education campaign" (#17)
- Build support among elected officials to apply pressure to managers (#18)
- Can feds break down state park barriers by providing funding, staff, etc. and framework that constrains the introduction. I.e., if it is becoming invasive, the feds deal with it (#19)

- Build private support and funding to ease concerns about management dollars being dedicated to managing new species (#20)

4.1 STRATEGY 2 RESULTS

Florida Keys Tree Cactus Barriers – This section shows all barriers identified by participants for three strategies related to the Florida Keys tree cactus. All barriers are classified based upon the STAPLEE method. Numbers following comments only represent the order in which they were entered, and do not denote priority or importance.

Strategy 2: Develop green roof cactus hammock ecosystem

Social
- Those who run or operate ideal buildings may not want the burden (#7)
- Public concern about intersection between endangered species management and private business interests (#8)
- Dislike of aesthetic of green roofs (#11)
- Possible concerns about aesthetics - towering cacti looming overhead, possibly blowing off during storms (#13)
- May be difficult to observe/interact with (#17)
- Concern that it is not "natural" (#24)

Technical
- Understanding specs of load-bearing potential, etc. (#1)
- How will this work with structural requirements of buildings in hurricane prone area? (#2)
- More "hands on" management need (e.g., irrigation, soil replenishment" (#3)
- Will microclimate be suitable for the species? (#10)
- Will anyone be allowed access to these "new" habitats - public (#26)

Administrative
- May not be willing to put a rare species in a manmade habitat with high exposure (#9)
- Willingness of state and federal agencies to engage in experiment with listed species (#18)

Political
- Promoting potential "up sides" from a mitigation perspective (e.g., energy use reduction if the roof gardens shade buildings) may be averse to some politicians (#19)
- Local officials' support for green roofs and/or introduction of endangered species to local area (#21)

Legal and Governance
- Will building codes allow for this? (#4)
- Would the buildings face penalty if anything happens to the cactus? (#14)
- Ensure consistency with take rules for plants (not import/export, remove from federal property, give for commercial purpose, not interstate commerce, (#15)
  - Might comply with state and local laws regarding exotics/invasive and rare species (#22)
- No longer part of a natural habitat (#25)

Economic
- Would probably require private contributions (#5)
- Likely somewhat costly to set up and maintain over time (#6)

- Likely to be costlier than establishing plants on the ground regardless of whose ground or what type (i.e., private vs public, natural vs. developed...) (#16)

Environmental

- Could be viewed as the domestication of the species (#12)
- species that could benefit might be isolated from new habitat (#20)
- Uncoordinated proliferation of species may lead to poor planning for species conservation (#23)

Keys Tree Cactus - Prioritization of barriers - **This section shows participants prioritization of barriers under** Strategy 2: Develop green roof cactus hammock ecosystem. **Participants were instructed to vote for the most critical barriers to overcome.**

Keys tree cactus - Strategy 2 - Across (top) Barriers (budget) sorted by Mean Resource: "Critical barriers". Total budget 5 for 25 items. Ratings submitted: 6. Total alloc. 30. Complete allocation required. List of items randomized.					
Nr	**Item**	**Mean**	**%**	**SD**	**ALOC**
1	Likely somewhat costly to set up and maintain over time	0.50	10.00	0.10	3
2	Those who run or operate ideal buildings may not want the burden	0.50	10.00	0.10	3
3	Will building codes allow for this?	0.50	10.00	0.10	3
4	Would the buildings face penalty if anything happens to the cactus?	0.50	10.00	0.10	3
5	More "hands on" management need (e.g., irrigation, soil replenishment"	0.33	6.67	0.09	2
6	Promoting potential "up sides" from a mitigation perspective (e.g., energy use reduction if the roof gardens shade buildings) may be averse to some politicians	0.33	6.67	0.09	2
7	Public concern about intersection between endangered species management and private business interests	0.33	6.67	0.09	2
8	Understanding specs of load-bearing potential, etc.	0.33	6.67	0.09	2
9	Willingness of state and federal agencies to engage in experiment with listed species	0.33	6.67	0.09	2
10	Will microclimate be suitable for the species?	0.33	6.67	0.09	2
11	Concern that it is not "natural"	0.17	3.33	0.07	1
12	Ensure consistency with take rules for plants (not import/export, remove from federal property, give for commercial purpose, not interstate commerce,	0.17	3.33	0.07	1
13	How will this work with structural requirements of buildings in hurricane prone area?	0.17	3.33	0.07	1
14	Likely to be costlier than establishing plants on the ground regardless of whose ground or what type (i.e., private vs public, natural vs. developed...)	0.17	3.33	0.07	1
15	Local officials' support for green roofs and/or introduction of endangered species to local area	0.17	3.33	0.07	1

Keys tree cactus - Strategy 2 - Across (top) Barriers (budget) sorted by Mean Resource: "Critical barriers". Total budget 5 for 25 items. Ratings submitted: 6. Total alloc. 30. Complete allocation required. List of items randomized.					
Nr	**Item**	**Mean**	**%**	**SD**	**ALOC**
16	Uncoordinated proliferation of species may lead to poor planning for species conservation	0.17	3.33	0.07	1
17	Could be viewed as the domestication of the species	0.00	0.00	0.00	0
18	Dislike of aesthetic of green roofs	0.00	0.00	0.00	0
19	May be difficult to observe/interact with	0.00	0.00	0.00	0
20	May not be willing to put a rare species in a manmade habitat with high exposure	0.00	0.00	0.00	0
21	No longer part of a natural habitat	0.00	0.00	0.00	0
22	Possible concerns about aesthetics - towering cacti looming overhead, possibly blowing off during storms	0.00	0.00	0.00	0
23	species that could benefit might be isolated from new habitat	0.00	0.00	0.00	0
24	Will anyone be allowed access to these "new" habitats - public	0.00	0.00	0.00	0
25	Would probably require private contributions	0.00	0.00	0.00	0

3.2 Keys Tree Cactus Barrier Solutions

Strategy 2: Develop green roof cactus hammock ecosystem.

Will microclimate be suitable for the species?

- Revising this to say, "Will cactus thrive on green roof?" (#1)
- Regular monitoring to assess conditions, alter management (#2)
- Pilot study (#3)
- test it out in a public place so the point can be made that climate change is driving this drastic of a potential solution (#4)
- Consider mimicking broader ecosystem on green roof, not just cactus nursery (#5)
- combine this study species with other species that could benefit from same approach (#6)
- for a "green roof ecosystem" other species/densities should be considered (#7)
- Have temporary covers available to deploy during high exposure times or temporary for establishment - like greenhouse mesh (#8)
- Pilot test multiple sites to test which conditions affect success (#9)
- long-term vegetation management, i.e. pruning, fertilization (#10)
- Remote sensing work to determine more ideal sites (#11)

Those who run or operate ideal buildings may not want the burden

- Can meaningful incentives be provided? (#12)
- Provide financial incentives such as reduced permit application fee, tax break, etc. (#13)
- FWS marketing campaign (#14)
- Require/incentivize green roofs as part of updates and/or new builds for public facilities like refuge visitor centers, city parking garages, etc. (#15)

- Possible engagement of public (e.g., schools) to engage, raising awareness of endangered species/climate change and giving opportunities for hands-on interaction with the management process (#16)
- For public-facing businesses, provide marketing incentives to give them exposure to potential customers. "USFWS says, check out Joe Blow Restaurant's green roof which is helping protect an endangered species." (#17)
- Work with architects interested in green building to promote rooftop gardens as part of their designs (#18)
- Work with HOA's and other groups that regulate how buildings look to promote idea of green roofs (#19)
- Improving costs of developing green roofs (#20)

APPENDIX 10. WS3 LOWER KEYS MARSH RABBIT

Lower Keys marsh rabbit Case Study *(Sylvilagus palustris hefneri)*
Federal Status: Endangered

Description: This small short eared rabbit, is found primarily in grassy marsh, prairie habitats, and the transition zone between coastal wetlands and uplands. This species is reliant on freshwater availability but are often found in the mangrove transitional zone. Essential habitat is being lost on the Key West naval base, and rabbit population numbers in coastal areas are wildly variable and often crash in the aftermath of disturbance events. However, these coastal sites quickly fill back in with new rabbit recruits. This may be due to freshwater areas nearby serving as a refugia, and repopulation source for the coastal populations. The long-term success of the marsh rabbit will require insuring continual freshwater availability. On Big Pine Key and other pine islands there is potential for freshwater availability at up to 3 feet of sea level rise, but the water would most likely be brackish by that point. Previous airfield conversion work on the naval base altered the hydrology of the site, resulting in local population increases for the marsh rabbit. This provided the insight that artificial wetlands can and likely will be utilized by the Lower Keys marsh rabbit.

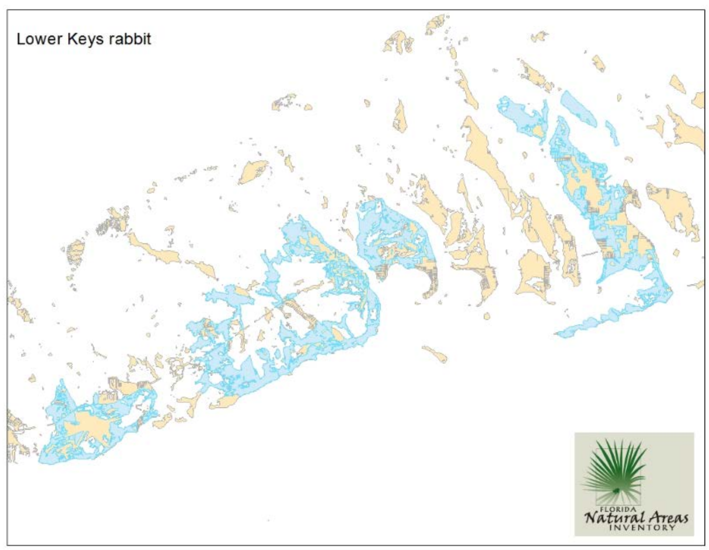


Figure 1. Known distribution of the Lower Keys marsh rabbit (blue). This map was produced by the Florida Natural Areas Inventory.

Table 1. Marsh rabbit results. The contents of this table represent the information generated during workshop exercises. The contents of the first three rows are the recommendations of species experts during Workshop 1, while the contents of row 4 are the priority actions determined by conservation practitioners in Workshop 2.

Consequences of Sea Level Rise	• High tides and salt water intrusion will affect coastal habitat – Big Pine Key. Herbaceous salt marsh may be transitioning into rocky intertidal habitat, which is not ideal • One major salinization event could wipe out freshwater access o 1 ft. Reduction of coastal habitat and freshwater availability o 2 ft. Further reduction of available habitat and freshwater decline o 3 ft. Most of habitat transitioned to mangrove, further freshwater decline – likely all sources brackish o 4 ft. Freshwater lost throughout current distribution
Proposed Adaptation Actions	• Fill in mosquito ditches • Restore freshwater regimes to improve marshes • Identify and prioritize most critical locations • Control predators such as cats and pythons • Leverage money to spend on military infrastructure to conserve and improve habitat. Utilize equipment military is using to improve infrastructure to create new habitat on the military land
Trigger Points and Monitoring	• When population drops to 50%, focus on increasing habitat quantity/quality (monitor via pellet counts & population size) • When Navy announces plans to elevate runways, this should trigger elevating marsh rabbit habitat
Managers Priority Actions	• Prioritize which mosquito ditches to fill for habitat benefit • Increase focus on keeping cats out of wildlife management areas • Use any infrastructure raisings or changes to artificially create new habitat – proven to work

Ex-Situ Considerations	• Develop Species Survival Plan and move into Association of Zoos and Aquariums management • Assisted migration from Lower Keys to Upper Keys • Assisted migration to managed lands in South Florida • Hybridization with mainland marsh rabbit (*Sylvilagus palustris*)

Table 2. Lower Keys Marsh Rabbit Rating

Participants were instructed to select their top three choices

Lower Keys marsh rabbit - Adaptation Strategies (multiple selection) sorted by Sum Criterion "Prioritize adaptation strategies". 3 selections of 7 items. Ratings submitted: 6. Total selections 18. Abstentions not permitted. List of items randomized.		
Nr	**Item**	**Selections**
1	Assisted migration from Lower Keys to Upper Keys	5
2	Increase predator control, particularly on wildlife management areas - cats, pythons	4
3	Assisted migration to managed lands in south Florida (allowing/planning on hybridization with mainland subspecies)	3
4	Leverage money to spend on military infrastructure to conserve and improve LKMR habitat	3
5	Restore freshwater regimes to improve marsh habitat for LKMR, prioritized based on critical habitat and potential impacts.	2
6	Create wetlands on areas of new infrastructure, raised in elevation in response to SLR (e.g., military lands)	1
7	Fill in mosquito ditches - prioritize based on locations of critical habitat	0

1.1 STRATEGY 1 RESULTS

Lower Keys Marsh Rabbit Barriers – This section shows all barriers identified by participants for three strategies related to the Lower Keys marsh rabbit. All barriers are classified based upon the STAPLEE method. Numbers following comments only represent the order in which they were entered, and do not denote priority or importance.

Strategy 1: Assisted migration to managed lands in south Florida (allowing/planning on hybridization with mainland subspecies

Social

- perception of us playing God (#2)
- People's social value for the species might be diluted by hybridization (#4)
- people not wanting the species in their backyard (#7)
- Which agency takes public responsibility for assisted migration? (#18)

- cat lovers won't be happy if they learn what is being prescribed for predator control in keys e.g., how cats are "managed" on public lands (#19)
- the focus on a single species might make it harder to get people to take an ecosystem focus (#32)
- NGOs or individuals might do it anyway if we don't (#33)

Technical

- Might cause both species to become less fit (#1)
  - Or more fit (hybrid vigor) (#31)
- are we able to catch the animals to move them and not have so much stress from the event that they get sick or die (#30)?

Administrative

- dealing with potential backlash or lots of calls and emails from the public (#16)
- Seems like an extremely complex administrative strategy - lots of red tape! (#28)

Political

- will political capital be there and is this the "right" species to use it on? (#13)
- not wanting to be the one to authorize translocation when there might be more important things (e.g., in the public's eyes) to spend funds on (#20)
  - yes, viewed as waste of funds (#27)
- Could political changes (e.g., change in state government) influence the available structural support (personnel and funding)? (#26)
- finding a political champion might be difficult. Opportunity?? perhaps use translocation to "relieve" some of the burden on residence or local govts in the Key's? (#29)

Legal and Governance

- There are long-term implications with ESA classifications with hybrid spp. (#6)
- implications of "introducing" an endangered spp on landowner property rights (#12)
- does this change of location raise challenges about which administrative unit is responsible? (#14)
- Sufficiently flexible rules/regs for multiple agencies to allow translocation into preferable lands (#34)

Economic

- potentially costlier compared to in situ (#8)
- costs associated with additional expertise... e.g., vets, animal welfare, outreach/education, local governments and public in new location (#22)
- Risk that money could be ill spent given the increase in predators on the mainland (e.g. pythons) (#23)

Environmental

- Risk of hybridization (#3)
- Loss of subspecies (#5)
- impact on the managed lands that they move to (#9)
- does the habitat exist on the mainland and ill it also be affected equally with climate change/SLR (#10)?
- risk of new diseases, predators, etc. in new area (#11)
- need to assess cost - benefit ratio (#15)
- What's the point? (#17)
- Still at risk from pythons... (#21)
- feral cats are everywhere (#24)
- Will we reach a goal in the RECOVERRY plan if we try this strategy? How do we measure that success (#25)?

Lower Keys Marsh Rabbit - Prioritization of barriers - **This section shows participants prioritization of barriers under** Strategy 1: Assisted migration to managed lands in south Florida (allowing/planning on hybridization with mainland subspecies. **Participants were instructed to vote for the most critical barriers to overcome.**

Lower Keys marsh rabbit - Strategy 1 - Across (top) Barriers (budget) sorted by Mean Resource: "Critical barriers". Total budget 9 for 32 items. Ratings submitted: 7. Total alloc. 63. Complete allocation required. List of items randomized.					
Nr	**Item**	**Mean**	**%**	**SD**	**ALOC**
1	Risk that money could be ill spent given the increase in predators on the mainland (e.g. pythons)	0.86	9.52	0.09	4
2	Risk of hybridization	0.71	7.94	0.08	4
3	risk of new diseases, predators, etc. in new area	0.71	7.94	0.08	4
4	the focus on a single species might make it harder to get people to take an ecosystem focus	0.71	7.94	0.10	3
5	impact on the managed lands that they move to	0.57	6.35	0.08	3
6	are we able to catch the animals to move them and not have so much stress from the event that they get sick or die	0.43	4.76	0.05	3
7	does the habitat exist on the mainland and ill it also be affected equally with climate change/SLR	0.43	4.76	0.05	3
8	There are long-term implications with ESA classifications with hybrid spp.	0.43	4.76	0.08	2
9	will political capital be there and is this the "right" species to use it on?	0.43	4.76	0.08	2
10	people not wanting the species in their backyard	0.43	4.76	0.12	1
11	feral cats are everywhere	0.29	3.17	0.05	2
12	need to assess cost - benefit ratio	0.29	3.17	0.05	2
13	not wanting to be the one to authorize translocation when there might be more important things (e.g., in the public's eyes) to spend funds on	0.29	3.17	0.05	2
14	Still at risk from pythons...	0.29	3.17	0.05	2
15	Sufficiently flexible rules/regs for multiple agencies to allow translocation into preferable lands	0.29	3.17	0.05	2
16	What's the point?	0.29	3.17	0.05	2
17	Will we reach a goal in the RECOVERRY plan if we try this strategy? How do we measure that success	0.29	3.17	0.05	2
18	implications of "introducing" an endangered spp on landowner property rights	0.29	3.17	0.08	1
19	costs associated with additional expertise... e.g., vets, animal welfare, outreach/education, local governments and public in new location	0.14	1.59	0.04	1

Lower Keys marsh rabbit - Strategy 1 - Across (top) Barriers (budget) sorted by Mean Resource: "Critical barriers". Total budget 9 for 32 items. Ratings submitted: 7. Total alloc. 63. Complete allocation required. List of items randomized.					
Nr	Item	Mean	%	SD	ALOC
20	Could political changes (e.g., change in state government) influence the available structural support (personnel and funding)?	0.14	1.59	0.04	1
21	my cause both species to become less fit	0.14	1.59	0.04	1
22	NGOs or individuals might do it anyway if we don't	0.14	1.59	0.04	1
23	perception of us playing God	0.14	1.59	0.04	1
24	Seems like an extremely complex administrative strategy - lots of red tape!	0.14	1.59	0.04	1
25	Which agency takes public responsibility for assisted migration?	0.14	1.59	0.04	1
26	cat lovers won’t be happy if they learn what is being prescribed for predator control in keys e.g., how cats are "managed" on public lands	0.00	0.00	0.00	0
27	dealing with potential backlash or lots of calls and emails from the public	0.00	0.00	0.00	0
28	does this change of location raise challenges about which administrative unit is responsible?	0.00	0.00	0.00	0
29	finding a political champion might be difficult. Opportunity?? perhaps use translocation to "relieve" some of the burden on residence or local govts in the Key's?	0.00	0.00	0.00	0
30	Loss of subspecies	0.00	0.00	0.00	0
31	People's social value for the species might be diluted by hybridization	0.00	0.00	0.00	0
32	potentially costlier compared to in situ	0.00	0.00	0.00	0

3.2 Lower Keys marsh rabbit Barrier Solutions

Strategy 1: Identify potential solutions for each barrier to implementation of this strategy for the Lower Keys marsh rabbit.

Risk of hybridization

- Translocate to marsh rabbit free zone (e.g., The Bahamas) (#1)
- Perhaps hybrid vigor (#3)
- Put them in zoos (#5)
- identify suitable habitat on mainland and remove all existing marsh rabbits and establish barriers to keep mainland marsh rabbits out. (#6)
- put a funky smell on their fur so only their own kind will mate with them (#9)
- remove federal protection for all translocated individuals so it won’t matter. (#10)
- put leashes on them so they can only mate within a set area (#11)
- Sterilize the mainland population into which you are translocating them (#12)
- Do it as cheaply as possible so failure is NBD (#14)

- Create a pet trade for them (#15)
  - But first breed them to have floppy ears (#19)
- translocate to another higher key w/o existing marsh rabbits (#17)
- Do studies on sexual selection and hybrid fitness to better understand implications (#20)

risk of new diseases, predators, etc. in new area

- translocate them in self-sufficient bubbles so they have food and are free from outside contact! (#2)
- Predator exclusion (#4)
- don't worry about it... do it because we are seen to be doing something (potentially knowing it won't work) which allows them to go extinct without being sued (#7)
- Careful selection of introduction area including monitoring existing rabbit population for disease and fitness (#8)
- put spikey collars on them so predators can't swallow them (#13)
- Control predators (#16)
- vaccinate translocated individuals (#18)
- ensure habitat suitability is of high enough quality that their recruitment rates outpace loss thru predation. (#21)

1.2 STRATEGY 2 RESULTS

Lower Keys Marsh Rabbit Barriers – This section shows all barriers identified by participants for three strategies related to the Lower Keys marsh rabbit. All barriers are classified based upon the STAPLEE method. Numbers following comments only represent the order in which they were entered, and do not denote priority or importance.

Strategy 2 - Increase predator control, particularly on wildlife management areas - cats, pythons

Social

- Bad press related to removing cats (#3)
- many (public) will see the removal of feral cats as inhumane (#4)
- we still haven't been able to overcome this with any wild species - birds, reptiles, etc. why would it work now? (#9)
- When people are focused on individual animals, saving rabbits at the expense of cats is a hard sell. You can't encourage an emotional response to rabbits while ignoring the emotional response to cats. (#10)
- control on pythons is difficult, and not the only species introduced in South Florida (#13)
- communicating effectively the downside of feral cats (#20)
  - communicating to local groups (#22)
    - communicating the issue of leukemia (#24)

Technical

- it is incredibly difficult to find pythons in the wild. very much a technical challenge that the experts have not been able to solve in the last 5-10 yrs. (#1)
- how can we effectively control predators? (#14)
- Rock pythons and other predators constantly being introduced (#15)
- if we take out these predators (BIG IF!!) then is there another predator waiting to come in and take its place (#16)
- means to control predators without creating a fenced island for the bunny (#23)

Administrative

Political

- removing feral cats is politically charged and a negative in some areas. (#2)

Legal and Governance

- No one wants to touch the cat issue! Political hot potato (#5)
- Most authorities already have the legal jurisdiction to remove cats (#7)
- challenge with who can capture/kill pythons in protected areas (#11)
- Create laws to keep cats inside (#17)
  - This will help to communicate the importance of keeping cats inside. (#19)
- in FL, people can have a max of 3 dogs. let's also limit the number of cats people can have (#18)

Economic

- python effective control is expensive and hard to measure. (#6)
- funds involved in trying to improve python detection. lots spent so far for very little return. detection rate now something like 0.05 (#8)
- advertisement campaign costs to educate public on releasing pythons, etc. into the wild, and about having cats outdoors (-- educate to stop both) (#21)

Environmental

- Negative consequences on other species from predator control strategies (#12)

Lower Keys Marsh Rabbit - Prioritization of barriers - **This section shows participants prioritization of barriers under** Strategy 2: Increase predator control, particularly on wildlife management areas - cats, pythons. **Participants were instructed to vote for the most critical barriers to overcome.**

Lower Keys marsh rabbit - Strategy 2 - Across (top) Barriers (budget) sorted by Mean Resource: "Critical barriers". Total budget 7 for 21 items. Ratings submitted: 7. Total alloc. 49. Complete allocation required. List of items randomized.					
Nr	**Item**	**Mean**	**%**	**SD**	**ALOC**
1	No one wants to touch the cat issue! Political hot potato	0.86	12.24	0.12	4
2	many (public) will see the removal of feral cats as inhumane	0.57	8.16	0.10	3
3	removing feral cats is politically charged and a negative in some areas.	0.57	8.16	0.10	3
4	in FL, people can have a max of 3 dogs. let's also limit the number of cats people can have	0.43	6.12	0.07	3
5	When people are focused on individual animals, saving rabbits at the expense of cats is a hard sell. You can't encourage an emotional response to rabbits while ignoring the emotional response to cats.	0.43	6.12	0.07	3
6	funds involved in trying to improve python detection. lots spent so far for very little return. detection rate now something like 0.05	0.43	6.12	0.10	2
7	python effective control is expensive and hard to measure.	0.43	6.12	0.10	2

Lower Keys marsh rabbit - Strategy 2 - Across (top) Barriers (budget) sorted by Mean Resource: "Critical barriers". Total budget 7 for 21 items. Ratings submitted: 7. Total alloc. 49. Complete allocation required. List of items randomized.					
Nr	Item	Mean	%	SD	ALOC
8	we still haven't been able to overcome this with any wild species - birds, reptiles, etc. why would it work now?	0.43	6.12	0.10	2
9	advertisement campaign costs to educate public on releasing pythons, etc. into the wild, and about having cats outdoors (-- educate to stop both)	0.29	4.08	0.06	2
10	control on pythons is difficult, and not the only species introduced in South Florida	0.29	4.08	0.06	2
11	Create laws to keep cats inside	0.29	4.08	0.06	2
12	if we take out these predators (BIG IF!!) then is there another predator waiting to come in and take its place	0.29	4.08	0.06	2
13	it is incredibly difficult to find pythons in the wild. very much a technical challenge that the experts have not been able to solve in the last 5-10 yrs.	0.29	4.08	0.06	2
14	Rock pythons and other predators constantly being introduced	0.29	4.08	0.06	2
15	Bad press related to removing cats	0.29	4.08	0.10	1
16	how can we effectively control predators?	0.29	4.08	0.10	1
17	challenge with who can capture/kill pythons in protected areas	0.14	2.04	0.05	1
18	communicating effectively the downside of feral cats	0.14	2.04	0.05	1
19	means to control predators without creating a fenced island for the bunny	0.14	2.04	0.05	1
20	Negative consequences on other species from predator control strategies	0.14	2.04	0.05	1
21	Most authorities already have the legal jurisdiction to remove cats	0.00	0.00	0.00	0

3.4 Lower Keys marsh rabbit Barrier Solutions

Strategy 2: Identify potential solutions for each barrier to implementation of this strategy for the Lower Keys marsh rabbit.

No one wants to touch the cat issue! Political hot potato

- work up communications strategy that emphasizes the health benefits of keeping cats indoors (#1)
- Intense communication campaign (#2)
- educational campaigns about cats outdoors (e.g., using the videos people have made from cat cams) to show how destructive they are (#3)
- Create laws that keep cats inside but, more importantly, communicate the need to keep cats inside (#4)

- encourage people to "adopt" a rabbit (symbolically) rather than a cat (#6)
- save YOUR cat from being killed by keeping them indoors. (#9)
- laws on max number of cats that can be owned (#14)
- Laws limiting the number of cats (#15)
- laws to capture all feral cats (#16)
  - yes, we would catch dogs running on the streets so should do for cats (#20)
- give people signs to display saying "I protect wildlife by keeping my cat indoors" (#18)
- Use the ESA to control cats (#19)
- emphasize that feral cats are disease vectors (are they?) (#21)
  - Feline leukemia communication campaign (#23)
- multi-tiered approach with: 1 source population where intensive predator control zones (e.g., public lands) where 100% of the predators are controlled, 2 - zone where pets must be kept indoors, and feral cats are occasionally trapped and removed, and 3 - zone where minimal cat control. (#25)
- create tech challenge for the public to come up with effective strategies (#31)
- Use fear and scare tactics (#35)

python effective control is expensive and hard to measure.

- spend decades researching effective predator control (#5)
- don't deal with pythons (so much money spent already to no end) so focus on cat issue (#7)
- get creative group together to develop novel predator control approaches (#8)
- Create better cat sterilization method (#10)
  - Feed them with kitty birth control laced food? (#17)
- encourage pythons to eat feral cats (#11)
- declaw all cats (#12)
- develop effective communication plan for stories of why cat control is necessary and the effects of not controlling cats (#13)
- use gene manipulation to sterilize pythons as is being attempted for exotic fish (#22)
- use something that keeps pythons or cats away? smells, predators, habitat??? (#24)
- Focus on core area at Naval base and enlist the military to collect pythons (derby) (#26)
- create more "jobs" by fostering a cottage industry of predator control companies that are trained and supported for demonstrated accomplishments. (#27)
- incentive program for communities (public) to develop control strategies/ideas -- like a tech challenge (#28)
- incentive program for the public to remove cats/pythons (#29)
  - enlist community groups for help (#30)
    - set up neighborhood watch to report pythons (#32)
- reward pet owners for doing proper management of their animals (#33)
- enlist poachers or former poachers to help come up with capture methods (#34)

1.3 STRATEGY 3 RESULTS

Lower Keys Marsh Rabbit Barriers – This section shows all barriers identified by participants for three strategies related to the Lower Keys marsh rabbit. All barriers are classified based upon the STAPLEE method. Numbers following comments only represent the order in which they were entered, and do not denote priority or importance.

Strategy 3: Leverage money to spend on military infrastructure to conserve and improve LKMR habitat

Social
- pro-environmental people might not support devoting money to the military (#4)
- a lot of money spent on military already so public might not get why spend more money on their bases, especially if the species might get blown up (#5)
- perpetuates the idea throughout the broader communities that the rabbits are "their" problem and not "mine". (#6)

Technical
- Can the military be trusted to maintain suitable habitat on their land, or will military goals change to reduce this suitability? (#1)
- can we access the lands to do surveys/checks when needed? (#8)
- what does it take to have authority to practice predator control? (#10)

Administrative
- the key here is to make sure none of the military operations are affected. (#7)
- can we monitor the progress of habitat and species conservation effectively on lands that are restricted? (#11)

Political
- What happens if/when the military leaves (#3)
- the opportunity to support the military and the environment at the same time may broaden the base of support (good), but may also splinter it (bad) (#12)

Legal and Governance
- Having to coordinate with military authorities and regulations might be difficult (#13)
- does the endangered status have implications to military operations (#15)?
- will the military be commanded from above to remove focus on protecting endangered species? (#16)

Economic
- Department of Defense (DOD) has "all" the bank - what does that leverage look like? more related to assurances? (#2)
- Opportunity: military will pay to do this (#9)

Environmental
- does lead from bullets negatively impact habitat? (#14)

Lower Keys Marsh Rabbit - Prioritization of barriers - This section shows participants prioritization of barriers under Strategy 3: Leverage money to spend on military infrastructure to conserve and improve LKMR habitat Participants were instructed to vote for the most critical barriers to overcome.

Lower Keys marsh rabbit - Strategy 3 - Across (top) Barriers (budget) sorted by Mean Resource: "Critical barriers". Total budget 5 for 16 items. Ratings submitted: 2. Total alloc. 10. Complete allocation required. List of items randomized.					
Nr	**Item**	**Mean**	**%**	**SD**	**ALOC**
1	Having to coordinate with military authorities and regulations might be difficult	1.00	20.00	0.00	2

Lower Keys marsh rabbit - Strategy 3 - Across (top) Barriers (budget) sorted by Mean Resource: "Critical barriers". Total budget 5 for 16 items. Ratings submitted: 2. Total alloc. 10. Complete allocation required. List of items randomized.					
Nr	**Item**	**Mean**	**%**	**SD**	**ALOC**
2	will the military be commanded from above to remove focus on protecting endangered species?	1.00	20.00	0.00	2
3	can we monitor the progress of habitat and species conservation effectively on lands that are restricted?	1.00	20.00	0.20	1
4	a lot of money spent on military already so public might not get why spend more money on their bases, especially if the species might get blown up	0.50	10.00	0.10	1
5	Can the military be trusted to maintain suitable habitat on their land, or will military goals change to reduce this suitability?	0.50	10.00	0.10	1
6	does the endangered status have implications to military operations	0.50	10.00	0.10	1
7	pro-environmental people might not support devoting money to the military	0.50	10.00	0.10	1
8	can we access the lands to do surveys/checks when needed?	0.00	0.00	0.00	0
9	DOD has "all" the bank - what does that leverage look like? more related to assurances?	0.00	0.00	0.00	0
10	does lead from bullets negatively impact habitat?	0.00	0.00	0.00	0
11	Opportunity: military will pay to do this to a great extent	0.00	0.00	0.00	0
12	perpetuates the idea throughout the broader communities that the rabbits are "their" problem and not "mine".	0.00	0.00	0.00	0
13	the key here is to make sure none of the military operations are affected.	0.00	0.00	0.00	0
14	the opportunity to support the military and the environment at the same time may broaden the base of support (good), but may also splinter it (bad)	0.00	0.00	0.00	0
15	what does it take to have authority to practice predator control?	0.00	0.00	0.00	0
16	What happens if/when the military leaves	0.00	0.00	0.00	0

Solutions were not created for this strategy, due to lack of time.

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