ATTACHMENT 16

Climate Change

December 24, 2014

Climate Change

"Warming of the climate system is unequivocal, and since the 1950s, many of the observed changes are unprecedented over decades to millennia. The atmosphere and ocean have warmed, sea level has risen, and the concentrations of greenhouse gases have increased. Human influence on the climate system is clear. This is evident from the increasing greenhouse gas concentrations in the atmosphere, positive radiative forcing (balance of incoming and outgoing energy), observed warming, and understanding of the climate system. Continued emissions of greenhouse gases will cause further warming and changes in all components of the climate system. Limiting climate change will require substantial and sustained reductions of greenhouse gas emissions" (IPCC, 2013).

The following scientific and ecological information on climate change and implications to U.S. Fish and Wildlife Service (Service or USFWS), was summarized by the National Climate Team and staff of the Service from the 2014 publication entitled *Climate Change Impacts in the United States: The Third National Climate Assessment* (NCA) (NCA, 2014). This team also summarized the 2013 publication from the IPCC entitled *Highlights of the IPCC 5th Assessment Report: The Physical Science Basis of Climate Change (WGI); Summary for Policymakers* (IPCC, 2013). This information is being further condensed with a primary focus on Florida. Florida is exceptionally vulnerable to sea level rise, extreme heat events, and hurricanes. With an ever growing population within Florida's coastal plain, annual visitors range from 10 to 15 million stressing the already decreasing water availability.

This climate change information is critical when conducting required USFWS analyses, conservation planning, and decision-making. Released by the White House on May 6, 2014, the NCA was prepared by a Federal Advisory Committee based on requirements of the Global Change Research Act of 1990.

Scenarios, Models, and Uncertainty

Our analyses under the Endangered Species Act include consideration of observed or likely environmental effects related to ongoing and projected changes in climate. As defined by the Intergovernmental Panel on Climate Change (IPCC), "climate" refers to average weather, typically measured in terms of the mean and variability of temperature, precipitation, or other relevant properties over time; thus "climate change" refers to a change in such a measure which persists for an extended period, typically decades or longer, due to natural conditions (e.g., solar cycles) or human-caused changes in the composition of the atmosphere or in land use (IPCC

2013). Detailed explanations of global climate change and examples of various observed and projected changes and associated effects and risks at the global level are provided in reports issued by the IPCC. Information for the United States at national and regional levels is summarized in the National Climate Assessment. Because observed and projected changes in climate at regional and local levels vary from global average conditions, rather than using global scale projections, we use "downscaled" projections when they are available and have been developed through appropriate scientific procedures, because such projections provide higher resolution information that is more relevant to spatial scales used for analyses of a given species and the conditions influencing it. In our analysis, we use our expert judgment to weigh the best scientific and commercial data available in our consideration of relevant aspects of climate change and related effects.

NCA projections and information about changes in climate are based on models that assume some initial conditions called "scenarios." Two of the scenarios used in the NCA to help frame the impact analyses in a consistent way are emissions scenarios and sea level rise scenarios.

Sea Level Rise Scenarios –The NCA relied largely on scientific literature available as of 2012 regarding projections of sea level rise (SLR), ranging from about 8 inches to 6.6 feet based on using different types of models and assumptions. The NCA projects that SLR will be an additional 1-4 feet in this century, noting that studies are still ongoing to understand processes that drive the melting of ice sheets.

Temperatures

According to the NCA, U.S. average temperatures have increased 1.3° - 1.9° F since record keeping began in 1895 (the range reflects differences in comparison methods); most of the increase has been since about 1970. The decade of 2000 – 2009 was the warmest on record and 2012 was the warmest year on record for the contiguous U.S. Temperature changes vary by location. Since 1991, average temperatures in south Florida have been greater than 1.5ºF, 1ºF to 1.5ºF in central Florida, .5ºF to 1ºF in northern Florida, and -.5º to +.5ºF over the Florida Panhandle.

Projected increases in average annual temperature by the late 21st century (compared to the late 20th century) vary from +3 to 7° F statewide depending on location and the emissions scenario used.

Extreme heat events in Florida are projected to increase relative to 1986-2005. By the late 21st century the average temperatures on the hottest days will be 3° F to 8° F. Due to human-induced emissions of GHGs that already have occurred, another +0.5° F increase in surface air temperature would be expected even if there was a sudden end to all GHG emissions caused by humans (Ch. 2, p. 25). Significantly more hot days (95°F or above) and fewer freezing events are projected. For the State of Florida, this equates to an increase of >50 days for western and southwestern Florida, +40 to 50 days for the interior of Florida, and +30 to 40 days for Florida's coastal areas.

A summary of historical and projected temperatures for Florida is compiled in Table 1 below from the 2014 NCA.

Temperatures Since 1895	U.S.	+1.3° to +1.9°F
Temperatures Since 1991	Florida Panhandle	-.5° to +.5°F
	Northern Florida	+.5° to 1.0°F
	Central Florida	+1.0° to 1.5°F
	South Florida	Greater than 1.5°F
Temperatures by 2100	Statewide	+3.0° to +7°F
Increased Extreme Heat Events	Statewide	+4.0° to +8.0°F
Increased Days over 95°F	Western Florida	Greater than +50 days
	Interior Florida	+40 to +50 days
	Eastern Florida	+30 to +40 days

Table 1: Historical temperatures for Florida with projections provided through 2100.

Ecological Implications of Temperature Increases

On-going and projected changes in temperature vary considerably in different locations and with seasonal variations. Thus, "downscaled" projections (at the county level or finer scale) for different seasons are more suitable and useful than global, national, or regional projections of average annual temperatures.

Species and habitats vary in how they respond to increasing temperatures. For example:

- Some species are physiologically capable of tolerating increased temperature, some will be able to adjust behaviorally, some will shift their ranges if dispersal is possible, some will eventually undergo genetic changes, and some will respond in a combination of ways.
- Studies have shown that some species may initially benefit from the early stages of a warming climate, but then deteriorate (Bertelsmeier, 2013).
- Microclimate conditions (e.g., climate refugia) at local scales can provide suitable locations for populations to persist even though the temperature in the surrounding area increases. Cooler springs with spring runs into rivers with coldwater upwellings in streams are examples of situations in which climate refugia may occur.
- Although some species may tolerate or adapt to increasing temperatures, there may be thresholds beyond which they are unable to adapt quickly enough, creating a risk of local or range-wide extinction due to higher temperatures or combinations with other stressors.
- For a variety of reasons, populations within a species can vary in response to increasing temperatures. We seldom have the information to identify such differences

in advance, thus analyses and planning typically assume that responses will be the same.

- Species that are more tolerant of increasing temperatures may be able to outcompete and displace other species in the same area. Some invasive species of plants and animals that tolerate higher temperatures already are increasing in abundance and/or distribution, and may become competitors or predators of native species, perhaps even displacing them.
- Habitat changes also will vary in relation to temperature. In many locations vegetation composition and structure is already changing. Changes will occur on different temporal and spatial scales, and will result in changes in habitat suitability for many species
- Increasing temperatures may alter the timing of species that migrate attitudinally, causing a cascading effect on other species in that ecosystem.
- High temperatures and prolonged drought can increase the risk and extent of wildfires.

Precipitation

Precipitation patterns are changing. The NCA reports that average precipitation has increased by +5 to +10% since 1900 in South Florida and 0 to +5% in northeastern Florida. However, decreases in precipitation have occurred in central Florida and the Florida Panhandle of -5 to -10%.

Heavy downpours are increasing, especially over the last 30 to 50 years. Increased inland flooding is predicted during heavy rain events in low-lying areas. Increases of up to 27% in the frequency and intensity of these events have occurred across Florida since the 1970s.

Precipitation projections are less certain, but many models project increases in precipitation during the Wet Season (rainy season) across southern Florida and the Caribbean are projected. Projections of future changes in precipitation show substantial shifts in where and how precipitation will fall. Models are in agreement regarding changes in tropical storm and hurricane rainfall events. Greater rainfall rates are expected with about a 20% increase near the center of storms. Scientists continue to research the expectation of precipitation changes in other severe storms. Historical precipitation and projections for Florida through 2100 are compiled in Table 2 below.

Rainfall Amounts Since 1900	Florida Panhandle	-5 to -10% of average
	Northern Florida	0 to +5% of average
	Central Florida	-5 to -10% of average
	South Florida	+5 to +10% of average
Increased Heavy Downpours since the 1970s	Statewide	+27%
Increased Annual Rainfall by 2100	Statewide	0 to +20%

Increased Dry Consecutive Days by 2100	Statewide	-10 to 20%
	South Florida	0 to +30%

Table 2: Historical rainfall patterns and projections through 2100 for Florida.

Newer climate model simulations using the CMIP5 models indicate changes of precipitation seasonally for the State of Florida.

State Region	Winter	Spring	Summer	Fall
Panhandle	0 to -10%	0 to +10%	0 to -10%	+10 to +20%
North Florida	0 to -10%	0 to +10%	-10 to -20%	+10 to +20%
Central Florida	0 to +10%	0 to -10%	-10 to -20%	+10 to +20%
South Florida	0 to +10%	0 to -10%	-20 to -30%	+10 to +20%

Table 3: Newer rainfall simulations using the CMIP5 models for regions within Florida.

Ecological Implications for Precipitation Changes
Although warming means larger amounts of water in the atmosphere, not all areas will get wetter. As discussed above, some areas could become drier. It is important to remember that climate change can trigger both droughts and floods. Flooding events will accelerate soil erosion and related impacts. Increased precipitation and/or flooding will impact certain species and their ability to forage and nest. These increases may also displace certain species.

Altered river flows will alter sediment transport and affect species distributions and productivity. Increased river flood magnitudes with flooding events will cause stress to fish and habitats, causing fish and other species to adapt their behaviors in riverine systems in a variety of ways.

Sea Level Rise

The NCA reports that global mean sea level rise (SLR) has been approximately 8 inches since 1880, the rate over the past 20 years has roughly doubled, and SLR is projected to increase another +1 to 4 feet (ft.) by the end of the 21st century. Global average SLR less than 8 inches or greater than 6.6 ft. by the end of the century is plausible.

SLR varies locally depending primarily on land subsidence or uplift in response to historic glacial activity across the continent. Storm surges and tides combine with SLR to increase flooding and erosion in many areas. SLR impacts coastal erosion, changes in sediment transport and tidal flows, more frequent flooding from higher storm surges, landward migration of barrier shorelines, fragmentation of islands, and saltwater intrusion into aquifers and estuaries.

SLR is expected to continue for many centuries at rates equal to or higher than those of this century due to past, current, and future emissions of GHGs (from human activities). GHGs result in warmer air which contributes to additional expansion of warmer ocean water and additional melt of ice sheets and glaciers. The range of the projection for another +1 to 4 ft. primarily reflects uncertainty about ice sheet melting. Historical and projected sea level rise (SLR) is compiled in Table 4 below.

SLR since 1880	Global	+8 inches	
SLR by 2100	Global	+12 to 48 inches (+1 to 4 feet)	NCA Projections
SLR by 2100	Global	+6.7 to 15 inches	IPCC Projections
SLR by 2100	Florida Statewide	+39 inches	FPLCC Projections

Table 4: Historical and projected sea level rise (SLR) through 2100.

Ecological Implications for Sea Level Rise
It is important to consider storm/tidal surge in combination with SLR, as storm/tidal surge impacts can be more substantial than SLR alone. National Wildlife Refuges in coastal areas will be increasingly impacted by SLR and storm/tidal surge. Sea level rise will increasingly lead to inundation of coastal wetlands in the region with saltwater intrusion likely through inland waterways and aquifers. Climate change is expected to increase harmful algal blooms and disease-causing agents in inland and coastal waters. Ecosystems such as tidal marshes and swamps are at risk from sea level rise. Some tidal freshwater forests are retreating, while mangrove forests are expanding.

Extreme Events

Extreme events are expected to increase in strength and frequency with accelerated climate change.

Drought
As mentioned in the Precipitation section, dry consecutive days are expected to increase 10 to 20% for most of Florida with up to 30% for South Florida.

Wildfires
In some areas, prolonged periods of record high temperatures associated with droughts contribute to dry conditions that are driving wildfires. Wildfires can cause drastic changes in species composition, changes in tree density, increased flooding and erosion risks, and decreased carbon storage capacity. The effects of climate change weaken the natural protections ecosystems have against these extreme events, making them more vulnerable.

Hurricanes
There has been a substantial increase in most measures of Atlantic hurricane activity since the early 1980s, the period during which high-quality satellite data are available. These include measures of intensity, frequency, and duration as well as the number of strongest

(Category 4 and 5) storms. The recent increases in activity are linked, in part, to higher sea surface temperatures in the region that Atlantic hurricanes form in and move through. Numerous factors have been shown to influence these local sea surface temperatures, including natural variability of the Atlantic Multi-decadal Oscillation (AMO), human-induced emissions of heat-trapping gases, and particulate pollution.

Tropical storms and hurricanes are projected to be fewer in number but stronger in force, with more Category 4 and 5 hurricanes. Almost all existing studies project greater rainfall rates in hurricanes in a warmer climate, with projected increases of about 20% averaged near the center of hurricanes. Models also project changes in hurricane tracks and where they strike land.

Ecological Implications for Extreme Weather Events
Extreme weather events are another impact of climate change likely to cause changes in the makeup and functioning of ecosystems. Climate change makes ecosystems less resilient, or harder for them to bounce back after they are impacted by extreme disturbances such as fires, floods, and storms. The changing climate's effects on extreme events are still an active and open area of research.

References

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