Case Study 1: Black Bears in Gulf Coastal Plains and Ozarks Landscape Conservation Cooperative

John Tirpak, Science Coordinator
Gulf Coastal Plains and Ozarks (GCPO) Landscape Conservation Cooperative

Location and Scale: As part of a comprehensive vulnerability assessment for a broad suite of priority species, the Gulf Coastal Plains and Ozarks (GCPO) Landscape Conservation Cooperative (LCC) plans to conduct a vulnerability assessment (VA) specific to the black bear. The planned VA will be spatially explicit, with the GCPO boundary serving as the overall study area and the five terrestrial subunits within this geography serving as focal areas for analysis.

The black bear was selected as a focal species because it has many characteristics that uniquely qualify it as a candidate for a VA:

1) It is one of the last large mammals within the region. Its large home range size and dispersal capabilities make it responsive to ecological processes and patterns at broader scales than most other species in the GCPO.
2) It is a species of broad interest. Bears are charismatic megafauna that capture the imagination of public (both hunting and non-hunting constituencies), state game agency personnel (from manager to executive), and federal partners (the *luteolus* subspecies is listed as endangered). This interest is reflected in the large number of bear-specific partnerships that exist just within this geography (e.g., Black Bear Conservation Coalition, East Texas Black Bear Task Force, etc.)
3) Adaptive capacity is potentially high (based on response in other regions, like the Northeast); however, populations remain low in South. Is it habitat-limited or is there some other aspect of its biology that increases its sensitivity or exposure to current stressors in the region. How is that likely to change?

The **objectives** of the black bear VA include:

1) Determine where population is generally headed with regard to projected changes on landscape. Will urbanization, climate change, and changing landuse (forestry, ag, etc.) halt, hinder, or help bears?
2) Given the current spatial structure and status of bear populations GCPO-wide, identify where the best places to focus efforts (and what should those efforts be) that balance the needs of today and the needs of tomorrow to achieve long-term bear population sustainability. In other words, where are bottlenecks of connectivity, populations blinking in or out, new opportunity areas likely to arise – and what should we be doing in response?

Status: Pursuit of a comprehensive VA for the GCPOLCC was approved by the Steering Committee at its June meeting. Initial conversations have begun to identify key partners, representative species (like the black bear), and a process for undertaking qualitative and (if needed) quantitative VAs. The Black Bear Conservation Coalition Executive Committee has been approached and is supportive, as is the lead biologist for the Louisiana black bear recovery team. Full engagement of community is envisioned in next 3-6 months.

Case Study 2: Monie Bay marshes

Patricia Delgado, Research Coordinator
Maryland Chesapeake Bay National Estuarine Research Reserve

Location: Mesohaline marsh-type located in Monie Bay, eastern shore of the Chesapeake Bay - Princess Anne, Somerset County, MD.

Scale/focus: The VA would be done for the marsh habitat of Monie Bay (which is one of the components of the Chesapeake Bay National Estuarine Research Reserve in Maryland - CBNERR-MD) - I am particularly interested in looking at the gradient between the low intertidal zone and the transitional zone with the adjacent uplands. We are already observing in some sites how the marsh is transitioning upland as a result of sea level rise. As part of the marsh habitat it would be interesting to take a closer look at the vulnerability of the 3-5 dominant marsh plant species.

Objectives: 1) To determine the vulnerability of the Monie Bay marsh to sea level rise and how changes may translate to impacts on the services this system provides to associated fauna and the people that live around the area. 2) Use this information to inform current management/protection of this area.

Status: The process has not started.

Case Study 3, North Inlet-Winyah Bay National Estuarine Research Reserve

Jen Plunket, Stewardship Coordinator
North Inlet Winyah Bay NERR

I have a potential case study to use for the exercise. We are only in the initial 'figuring out how to do this' planning stage of this project (which is why I am attending the training).

The North Inlet-Winyah Bay National Estuarine Research Reserve (NERR) target watershed encompasses 1,174 km2 of coastal habitats, including estuarine emergent marsh, brackish intertidal marshes, palustine forested wetlands, and barrier beach communities in South Carolina. These habitats
support fisheries, water quality, biodiversity, recreation and provide storm surge buffers, but the ways in which climate change and sea level rise will affect these habitats and the essential ecosystem services they provide have not been examined locally. Conservation planning efforts require knowledge of the vulnerabilities and potential responses of these habitats to current and future climate stressors. The purpose of this assessment is to inform local land conservation planners, land managers and policy makers of the potential sensitivity, exposure and adaptive capacity of species and habitats within the North Inlet-Winyah Bay NERR watershed. Additionally, this project will serve as a pilot of a methodology for assessing vulnerability at a reserve appropriate scale, and the findings, techniques, and lessons learned will be shared with the NERRS network.

Case Study 4, Lewis and Clark National Historic Trail

L. Suzanne Gucciardo
Natural Resource Specialist, Lewis and Clark National Historic Trail

I am the natural resource person for the Lewis and Clark National Historic Trail, and therefore have interests that range through five major bioregions (an adaption of Bailey's provinces). Our partners include a number of Federal agencies (many of whom are already involved in VA through the developing LCCs), as wells as state, county and even municipal park programs. It is my understanding that the Vulnerability Assessment process takes a broad landscape-scale approach to analysis. It is my hope that this can be scaled down to meet the needs of agencies and organizations that have more limited lands, responsibilities and budgets.

Location: Missouri River Basin, trans-mountain areas of Montana and Idaho, Lower Snake and Columbia River Basins (St. Louis to Oregon coast)

Scale/focus: Overall scale is about 1/6 the North American continent. Focus is local or regional park and conservation lands.

Objective: Provide a means for resource managers at the local level to understand the probable changes due to climate alteration and how that will impact their missions, management practices and budgets.

Status: Purely conceptual at this time. However, it is likely the VA process would be pursued with partners that have no budgets and limited staffing for such analysis.

Case Study 5, Weeks Bay National Estuarine Research Reserve

Michael Shelton, Coastal Training Program Coordinator
Weeks Bay National Estuarine Research Reserve
(Abridged version of a submitted proposal)

(1) Project Title (tentative)

Climate Change Vulnerability Assessment for the Weeks Bay National Estuarine Research Reserve: Understanding Potential Impacts and Planning for Adaptation

(2) Lead Principle Investigator

Michael Shelton, michael.shelton@dcnr.alabama.gov or 251.928.9792.

Principle Investigators

Scott Phipps, Research Coordinator, Weeks Bay National Estuarine Research Reserve
Patrick Crist, Director CPEM, NatureServe
Sarah Carr, Ecosystem-Based Management (EBM) Tools Network

(3) Statement of Problem

The Weeks Bay National Estuarine Research Reserve (Reserve) in Alabama was established in 1986 as part of a system of twenty-eight research and education facilities throughout most of the US coastal states. Weeks Bay is a subestuary of Mobile Bay and an Outstanding

National Resource Water. Over 7,000 acres of water bottoms, uplands, wetlands and fresh and salt water marshes are included within the Reserve boundary and properties managed by the Reserve partners. Reserve property encompasses one of the longest natural shorelines on Mobile Bay. On the portion of the Reserve's campus that is accessible to the public are located a visitor center including administration offices, two training buildings, research dormitory space, a laboratory and maintenance areas. In addition to the buildings, several miles of raised interpretive boardwalk trails and ground trails enable visitors to walk amongst and appreciate the various habitats. Impacts caused by climate change on the ability of the Reserve to conduct and facilitate long-term research, to disseminate science-based information and to conserve ecologically sensitive lands are currently unknown. Due to its proximity at or near sea level, the Reserve is exposed to coastal storms and flooding. The Reserve has emergency planning in place to respond to these natural weather events, yet its vulnerability to future events that may be exacerbated by rising sea levels and other climate-related stressors is not understood. The need for a detailed assessment using previously validated methods is acute as the Reserve enters its second twenty-five years of service. Assessment of impacts on the natural areas throughout the Reserve is required. Increase in shoreline erosion and loss of salt marsh habitat are likely in response to climate stressors. In addition, the impacts caused by the migration of shorelines along privately held waterfronts could have far reaching effects on bay ecology. Loss of already identified habitat of ecologically valuable plant and animal species is a legitimate concern as sea levels rise. The fate of mission-critical infrastructure currently at the water's edge or at low elevations in the face of multiple climate stressors is unexplored. Also, The Reserve recently completed a master plan outlining future development and land areas for restoration. Investigation of future vulnerabilities in the face of planned additions needs to be conducted. Climate stressors will influence management decisions and programmatic directions at the Reserve.

(4) Summary of Planned Work

Work will include a climate vulnerability assessment of Weeks Bay Reserve and the watersheds surrounding Weeks Bay conducted by NatureServe. NatureServe is a non-profit scientific services organization that provides data and analytical services and has considerable experience integrating climate change into assessments and planning. The vulnerability assessment will utilize methods already implemented on US Fish and Wildlife Service (FWS) Refuge Vulnerability Assessments. Also, NERR sites in the Northeast, Southeast and Texas have partnered with NatureServe to propose similar assessments at their sites. A detailed process that includes characterization of current conditions, identification of data needs, forecasting impacts caused by climatic change and other stressors and development of strategies for adaptation. Reserve staff will provide existing data including extensive System-Wide Monitoring Program (SWMP) data collected using standard methods over the NERR system. Adaptation planning will follow, utilizing results of the vulnerability assessment. The Reserve has a network of partners from Federal and non-Federal agencies, the Coastal Zone Management Program and nongovernmental organizations that serve on its Advisory Board and Restoration Advisory Committee. These groups will assist in developing the adaption plans and review the strategies as they mature. In addition, the Dauphin Island Sea Lab, Bon Secour National Wildlife Refuge and

the FWS Daphne (AL) Field Office have partnered with the Reserve on past projects and will provide technical support to this project. Using this project as a pilot, it may then readily be expanded to incorporate other conservation units. The Coastal Training Program at the Reserve has an effective partnership with Sea Grant, the National Estuary Program, the Gulf of Mexico Alliance and a Regional Training Program implemented by the five Gulf Coast NERR sites offering training in the coastal area. Following the development of an adaptation plan, training courses and evaluation processes will be created and implemented targeting first the Reserve staff, then training partners and coastal decision-makers. The approximate cost of this project is **$185,000 over a three year period**. An estimated $100,000 will be spent on the vulnerability assessment and adaptation planning process. The remaining $85,000 will be used to develop additional evaluation procedures and training courses and materials with assistance of training partners and EBM Tools Network. Training courses will be conducted after development. Combining the proven expertise of NatureServe, EBM Tools Networks, Weeks Bay Reserve and the established network of partners will lead to successful implementation of the components proposed in this project.

Case Study 6: Assessing Vulnerability of Fish Stocks to Climate Change

Brett Wiedoff, fishery policy analyst
NMFS Sustainable fisheries division

Location: Pilot test in NMFS regions with the potential of being used nationally
Scale/focus: Vulnerability of marine fish stocks to climate change
Objective: The goal of this workshop is to create a methodology applicable across all NMFS regions that efficiently assess the vulnerability of fish stocks to climate change.
Status: Draft methodology is currently being developed. An expert working group will meet to discuss the methodology in late September. After the methodology is refined, the methodology will be pilot tested in one to two regions around the nation.

NOAA's project plan:

Goal:

The goal is to provide fisheries managers with a practical tool for efficiently assessing the vulnerability of fish stocks and associated fisheries to climate change. The information provided will allow managers to identify the fish stocks most vulnerable to the impacts of climate change and effectively prioritize science and monitoring activities for these stocks.

Objectives:

1. Develop draft methodology for assessing the vulnerability of fish stocks with input from regional scientists and fishery managers.
    - Research current knowledge and identify potential approaches
    - Identify and create steering committee and expert working group
    - Complete draft methodology and identify where input from the working group is required
    - Host meeting with expert working group to discuss and modify methodology
2. Test methodology by conducting pilot project in two NMFS regions.
    - Host meeting in each region

- Revise method

3. Finalize methodology, build awareness, and conduct trainings.
    - Send draft tech memo to working group for review
    - Submit tech memo for review and publication
    - Create web based toolbox
    - Host trainings

Benefits to NMFS:

Providing fisheries managers with a tool for rapid assessments of fisheries vulnerability to climate change will help NOAA Fisheries address the growing number of Administration (e.g., Executive Order 13514) and judicial directives to federal agencies to assess vulnerability and develop adaptation plans to fulfill agency missions in a changing climate. The project is an important step to reduce the risk of (1) implementing fishery management plans that may not be achievable or sustainable, (2) experiencing unexpected long term negative impacts to fishing communities dependent on stocks that have moved or become less productive, and (3) receiving legal challenges to management decisions for not adequately considering climate change in fisheries management.

Rationale:

Climate change is already impacting the nation's living marine resources (LMRs) and the U.S. communities that depend on them. Climate-related changes such as increasing ocean temperatures, changes in ocean circulation, loss of sea ice, rising sea levels and ocean acidification have been implicated in the shifting distributions, abundances and phenology of fish stocks in many U.S. marine ecosystems. These impacts are expected to significantly increase in the future, increasing the need to understand which fishery resources are most at risk in a changing climate, and incorporate this information into stock assessments, rebuilding and management plans for successful fisheries management.

At present, few of NOAA's stock assessments and fishery management plans incorporate impacts of climate change on marine ecosystems leaving the agency at risk of setting targets and management plans for climate, marine ecosystem and fishery conditions that no longer exist. This increases the risk that (1) rebuilding plans and other management goals may not be achievable or sustainable and (2) there may be legal challenges to management decisions for not adequately considering climate change in fisheries management.

In the face of these changing conditions, fishery managers need an efficient way to quickly assess and predict the vulnerability of fish stocks and fisheries to impacts of climate change on marine ecosystems. While there are a variety of efforts underway to better understand and predict the impacts of climate change on marine ecosystems and fish stocks, there is no current tool or protocol to assist fishery managers in efficiently assessing the relative vulnerability of many fish stocks across each region.

Building on similar efforts for fisheries management in Australia and other areas, this project will directly address these needs by developing a relatively low cost tool for conducting rapid vulnerability assessments for fisheries in a changing climate, helping fishery managers to identify high vulnerability stocks and more effectively target limited research and assessment resources on stocks of highest concern. It will also provide a framework that additional information on climate vulnerability and impacts on fisheries can be built into.

Methodology:

After an extensive review of the literature, we have identified two existing models that can serve as the basis for developing our vulnerability assessment tool. Chin et al. (2010) uses a risk assessment model to analyze the vulnerability of Australian sharks to climate change, and Johnson and Welch (2010) outline a similar method for calculating the vulnerability of fisheries. We will convene an expert working group to help us modify these methods to fit the conditions in the U. S. If possible, we would like to create a tool that can be adjusted to match the regional knowledge base; where areas with little data can use expert opinion and qualitative analyses, and areas with additional data can create more quantitative analyses.

Products:

1. Methodology
2. Pilot projects (to test methodology)
3. Tool box

Organization:

Steering Committee (*Senior advisors that provide guidance on limited basis)*

- Galen Tromble, Sustainable Fisheries
- Kenric Osgood, Science and Technology
- TBD, Habitat Conservation
- Steve Leathery, NEPA
- Rick Methot, Stock Assessment Expert

Project Management Team (*Lead and complete project*)

- Mark Nelson, SF3, Co-Project Lead
- Dr. Wendy Morrison, SF3, Co-Project Lead
- Roger Griffis, ST7, Strategic coordinator/editor/writer/S&T
- Dr. Jonathan Phinney, SWSC, Lead consultant /editor/presenter
- Dr. Wes Patrick ,SF3, Reviewer/consultant with experience (PSA success)
- OHC member, TBD

Expert Working Group (P*rovide feedback via workshops and review draft report; Members TBD*)

- 6 Fisheries management experts (1 from each region)
- 6 Stock assessment/ecosystem scientists (1 from each region)
- 2-3 Climate science experts
- 1-2 Habitat experts

Budget Needs:

- Expert working group ($50,000)
- Regional workshops (2 regions):
    - Travel for SF HQ (2 people *2 regions *~$1500 per trip = $6,000)
- Publication cost ($1,000)
- Trainings (on-line only or possible travel needed). Attend 8 council meetings and 1 National SSC meeting in 2012 ($0 - $15,000)
- NMFS Toolbox program (staff time, takes 6 months)

Risk Management *(potential issues that can derail or slow down project)***:**

- Loss of dedicated staff time (core team)
- Availability of regional experts/lack of engagement by workgroup
- Lack of support/funding for workshop

References:

Chin, A., P. M. Kyne, T. I. Walker and R. B. McAuley. 2010. An integrated risk assessment for climate change: analyzing the vulnerability of sharks and rays on Australia's Great Barrier Reef. Global Change Biology 16: 1936-1953.

Johnson, J. E. and D. J. Welch. 2010. Marine fisheries management in a changing climate: A review of vulnerability and future options. Reviews in Fisheries Science 18: 106-124.

Project Timeline

		2011							2012												2013										
Obj #	Activity	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul
1	Research problem and approaches																													
1	Create project plan, briefing document, and get steering committee approval																													
1	Identify and create expert working group																													
1	Complete options paper that identifies preferred method																													
1	Host meeting with expert working group to modify methodology																													
1	Revise method																													
2	Test approach using 2 regions. Host meeting in each region																													
2	Revise method and write draft report																													
3	Draft report completed and sent to expert working group for review																													
3	Complete final draft. Start tech memo/peer review process																													
3	Build capacity for use. Host trainings and create web based toolbox.																													
3	Final report/paper published																													
3	Regions use framework																													
3	Assess and improve																													

Case Study 7: Rio Grande Cutthroat Trout

Andrew Todd, Research Biologist
U.S. Geological Survey Crustal Geophysics and Geochemistry Science Center

Native trout and salmon are often considered to be keystone species for aquatic and terrestrial ecosystems, and because they have narrow thermal tolerances, they provide an excellent early warning indicator of climate warming. In the Western US, as the climate changes, native cutthroat trout will be confronted with changing conditions and stressors throughout their range that include loss of thermally suitable habitat, population fragmentation, and detrimental interactions with nonnative salmonids. Due to diverse threats and the currently fragmented distributions of these cutthroat sub-species, informed predictions of expected stream conditions under future climate scenarios will assist state and federal land managers as they

seek to assess the climate-vulnerability of existing populations, and coordinate well-informed conservation and restoration activities moving forward.

The Rio Grande cutthroat trout (RGCT) is the southern-most subspecies of cutthroat trout in the Western U.S., endemic to the Rio Grande, Pecos, and Canadian River basins in Colorado and New Mexico. Historically the subspecies occupied over 10,000 km of streams in this region, but currently occupies less than 12% of its historical range (1,500 km) with as few as 120 remaining conservation populations, many of which are in streams surrounding Colorado's San Luis Valley. In 2008, the RGCT was added to the Endangered Species Act Candidate List, and the potential negative effects of climate change on this subspecies (warming temperatures, changes in flow) were discussed in detail in the listing package (see Scanning the Conservation Horizon, pg. 18). Briefly, the listing package noted that increasing stream temperatures will likely decrease available thermal habitat for the subspecies, with diverse consequences for the RGCT, including increased interaction with non-native salmonids, increased susceptibility to pathogens, increased population fragmentation, and lost life history variation.

The diverse interest in the conservation of the RGCT is evident in the interagency species conservation team that has been assembled to strategically address the stressors to the fish across its large landscape distribution. For example, by nature of its scattered distribution on diverse private, state, and federal lands, the conservation team for the RGCT includes multiple members from two states (CO, NM), four federal agencies (USFWS, USFS, BLM, NPS), and several tribes. Public lands constitute the majority of RGCT stream miles, with more than half of the total miles of existing, occupied RGCT habitats falling on USFS lands (54%) (Alves et al. 2008). Importantly, while the RGCT conservation team has meticulously quantitated many of the current risks to conservation populations of this fish (e.g. catastrophic disease risk, genetic contamination risk, general population health), future risks from climate change to essential trout habitat parameters (i.e. trout need sufficient water that is cold) have been evaluated more qualitatively to date.

Our research group (USGS, New Mexico State University) has been funded by the USFWS to help to conduct a more quantitative evaluation of the vulnerability of the RGCT to various physical habitat conditions that are likely to change with a changing climate (water temperature regime, baseflow hydrology, wildfire).

Case Study 8: Lake Mead desert tortoise VA

Sandee Dingman, Natural Resource Specialist
Lake Meade NRA

Target species: Desert tortoise (*Gopherus agassizii*), federally listed as threatened in Nevada as the Mohave population and new candidate for listing in Arizona as the Sonoran population

Location: Lake Mead NRA (1.5 million acres in Nevada and Arizona, Mojave Desert landscape)

Scale/Focus: Parkwide in order to inform the park's Resource Stewardship Strategy which will guide resource management actions for next 10-15 years

Objective: Provide for persistence of desert tortoise by maintaining existing desert tortoise habitat that is likely to serve as future refugia and providing connectivity to surrounding tortoise habitat that is likely to remain or become suitable under future climate conditions.

Status: New start. We've done some ecological niche modeling with a university cooperator to identify locations that are likely to serve as refugia or future tortoise habitat, but this is just one approach to one aspect of the issue. Lots of room to do more and we haven't really given a lot of thought to other approaches.

Case Study(ies) 9: Alaska!

Bob Winfree, Science Advisor
National Park Service, Alaska Regional Office

Glacier Bay, Kenai Fjords

Identify habitats and potential refugia for marine mammals and marine birds that are potentially susceptible to climate warming, ocean acidification, sea and ground level change. Harbor seals are a vitally important traditional species to Alaska Natives and a highlight for visitors who see these parks from cruise ships or small boats. Protection of seals and their pupping habitat are important resource and vessel management goals for these parks. In 2012, the National Marine Fisheries Service will also recognize Glacier Bay harbor seals as a genetically unique and geographically separate stock. Climate-related coastal ice loss and retreat of tidewater glaciers directly impact available pupping habitat, and could decrease seal pup survival through exposure and predation. The assessment would provide information to protect habitats and potential refugia for seals and associated marine mammals that are potentially susceptible to effects of ice loss, ocean warming, and relative sea level change.

Gates of the Arctic, Lake Clark, Wrangell St. Elias -

Assess rapidly-thawing perennial ice patches for exceptionally-preserved archaeological and biological remains, develop and implement data recovery plans where appropriate. Thawing ice patches are rare time capsules of ancient frozen organic remains predating EuroAmerican exploration of Alaska. Native Alaskan culture and history are primary interpretive foci for national park visitor centers in Northern Alaska (e.g., Fairbanks, Kotzebue, Nome, and Barrow). The densest known concentration of archaeological sites in Northern Alaska is in GAAR and spans the entire duration of human occupation since the last Ice Age (about 12,000 years). This project would enable assessments of archaeological resource vulnerability, including rare organic tools and biota preserved through freezing, due to climate-induced landscape changes, thermokarst formation, thawing permafrost, dramatic water level change, and melting alpine snow patches.

Bering Land Bridge, Noatak

Identify key habitats of caribou and reindeer in Western Alaska, caribou migratory routes, potential barriers, protected or managed corridors that would preserve free ranging herds and

subsistence opportunities for Native and rural communities, and facilitate range shifts for Arctic plants and other species as the favorable climate envelopes for these species shift northward.

Klondike Goldrush, Wrangell St.-Elias, Glacier Bay, Katmai.
This assessment would enable climate assessments of current and potential future habitat for several rare wildlife species in Southern Alaska. Amphibians and bats are temperature-limited and relatively rare species in Alaska. Concern for limiting impacts to these species has affected scheduled maintenance of visitor facilities and visitor access to some park locations.
Alternative hypotheses suggest that climate warming could benefit these species through natural range expansion, or further stress isolated populations through habitat change, disease expansion (e.g., white nose disease of bats, chytrid fungus of amphibians), or other factors.

Lake Clark, Katmai, Aniakchak
Identify freshwater salmon habitats that are potentially at risk due to increasing stream temperatures, seasonal changes in water flow, landcover change, changing fire regime, and encroachment

Cape Krusenstern, Bering Land Bridge, Klondike Goldrush
Assess vulnerability of coastal archaeological sites. Coastal parks contain unparalleled records of human activity since the last Ice Age, and of early settlements before and during EuroAmerican exploration. Many sites are at severe risk of loss due to rapid coastal erosion, permafrost thaw and subsidence, and sea level rise. Boreal forests, permafrost and fire

Case Study 10: Hine's Emerald Dragonfly *(Somatochlora hineana*)
Kris Lah

Current range: IL, MI, MO, WI

Objective: Conducting 5-year review, may rewrite/revise recovery plan, considering reintroduction/augmentation

Habitat: Groundwater federal wetlands, groundwater required for larval stage (first 4-5 years), shallow depth to bedrock (dolomitic limestone), crayfish burrows.

Threats: groundwater depletion (e.g. increased use and decreased infiltration), invasive species, vehicle collisions, flooding, sedimentation, degradation of groundwater quality.

Note: brief drought period during summer months appears to be required for species competitive advantage over other dragonflies. Prolonged drought can be detrimental to young age classes.

Habitat maintenance: requires prescribed burns and herbicide application.

Status: Just starting to think about it, but it needs to be done because of the 5-year review