Case Study 3. Species Vulnerability Assessment for the Middle Rio Grande, New Mexico

Summary

This case study describes a method for scoring terrestrial species that have potential to be vulnerable to climate change. The assessment tool seeks to synthesize complex information related to projected climate changes into a predictive tool for species conservation. The tool was designed to aid managers in prioritizing species management actions in response to climate change projections. We describe an application of the scoring tool to terrestrial species in a specific geographical region, the Middle Rio Grande of New Mexico, and provide a synopsis of the results of this regional assessment.

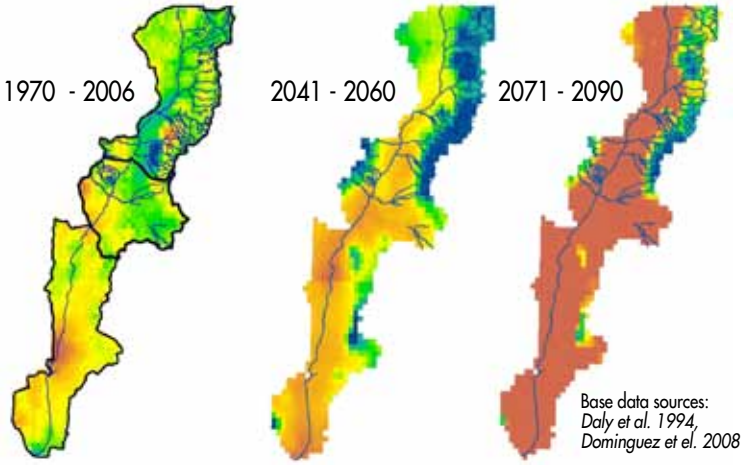

Figure C3.1. Current and future moisture stress in Upper and Middle Rio Grande. 1970—2006 = trend in moisture deficit. Preliminary future forecast: 2041–2060 = departure (difference) in deficit relative to 1951–2006 baseline; 2071–2090 = departure in deficit relative to 1951–2006 baseline (Bosque Working Group 2008).

Background

Land managers need adaptation and mitigation strategies to manage species within the context of ecosystem responses to a changing climate and varying responses of individual species. The U.S. Forest Service Rocky Mountain Research Station (RMRS) in Albuquerque is creating scientifically based decision-support tools for managers to anticipate climate-related changes and respond strategically to managing those effects. Vulnerability of species and populations to changes induced by global warming will be assessed using a scoring system being designed by RMRS. This system assigns scores from synthesized information related to the probability of climate-related population declines due to a number of factors, including: natural disturbances (e.g., flooding, wildfire); breeding requirements (e.g., link with seasonal food resources, breeding ponds); nonbreeding requirements (e.g., habitat changes, stopover sites); dispersal potential (e.g., connectivity of habitats, mobility); and exacerbating factors (e.g., rarity, proximity to human populations). Scores for an individual species are then combined to create an overall prediction of vulnerability to climate change.

Lead authors: Deborah M. Finch, Megan M. Friggens, and Karen E. Bagne.

The Bosque or riparian forest along the Middle Rio Grande has high value for wildlife but because of competing land and water uses is also vulnerable to degradation. Global climate predictions include higher temperatures in the Southwest, more variable rainfall, and more drought periods, which are conditions that will exacerbate the present issues (Christensen et al. 2007). Moisture stress along the Upper and Middle Rio Grande is projected to increase dramatically through this century (Figure C3.1). In addition, human populations in the region are expected to grow considerably, putting more pressure on natural systems competing for resources. Management actions can often be taken to mitigate impacts, but is most effective when scientifically based and anticipatory rather than reactionary. Land managers for the Middle Rio Grande Bosque would benefit from knowledge related to projected effects of climate change on species in their area. Depending on actions and magnitude of climate change effects, this strategy will help conserve biodiversity.

Purpose

This case study documents a new method for assessing the relative risk to persistence of individual species under projected changes in temperature, precipitation, and related climate phenomena (Bagne and Finch 2008). The RMRS assessment consists of a scoring system focused on simple predictive criteria for terrestrial vertebrate species and was specifically designed to be applied by managers. Relative vulnerability is assessed through the use of scores generated for individual species. The assessment is a flexible system that allows the user to incorporate data and information from a variety of sources. In addition, new information can be incorporated into the scoring process as climate modeling becomes more sophisticated and predictions more precise. Identification of the most vulnerable species, those with the highest scores, is one step toward implementing an effective management program.

In this case study, we summarize results from a final report (USDA Forest Service RMRS 2010) delivered April 2010 to our sponsors, U.S. Fish and Wildlife Service Region 2 (Bosque Improvement Initiative) and the U.S. Forest Service, Washington Office. The final report describes an application of the tool to species in a specific geographical region known as the Middle Rio Grande.

Conservation Objective

Global climate change has the potential to affect habitats and species worldwide within a relatively short period of time and, in fact, appears to already be altering ecosystems (reviewed by McCarty 2001; Peñuelas and Filella 2001; Root et al. 2003). In addition to current conservation challenges such as habitat loss, toxins, and exploitation that have long been part of species management programs, current climate change is relatively new and its impact is expected to grow. Already a number of species have been identified as at risk to changes in climate in New Mexico. With increasing droughts projected, populations of those species sensitive to drought conditions such as white-tailed ptarmigan, southwestern willow flycatcher, and Goat Peak pika are likely to decline (Enquist and Gori 2008). Particular habitat types, such as alpine tundra, are expected to decline along with the species dependent on them (Walther et al. 2005).

Assessment Targets

This assessment focused on the terrestrial vertebrate species occupying riparian habitats (known locally as "the Bosque," a Spanish word meaning "forest") along the Middle Rio Grande in New Mexico. This area is bounded by Elephant Butte Reservoir to the south and Cochiti Dam to the north. We created a future climate scenario for the Middle Rio Grande Bosque as well as upland areas surrounding the Bosque. Vertebrate species for the region were initially identified using the *Field Guide to the Plants and Animals of the Middle Rio Grande Bosque* (Cartron et al. 2008). Archival Middle Rio Grande data on birds, amphibians, reptiles, and bats (from D. M. Finch, RMRS) were also used to identify species for scoring. We removed species that were not resident within the Middle Rio Grande Bosque for at least part of the year, as well as those species that occur primarily in upland habitats. Rare species were included only if they were known to breed within the Bosque. Species that used the riparian corridor solely for migration, or otherwise had an intermittent or transient presence within the Bosque, were not included in the assessment list.

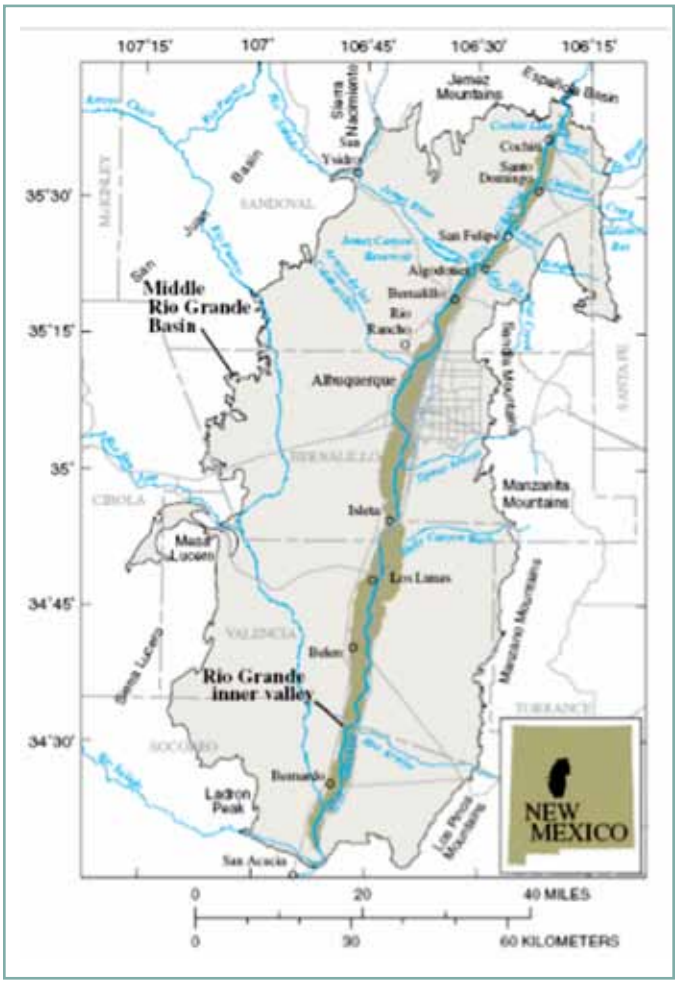

Figure C3.2. Major physiographic and hydrologic features of the Middle Rio Grande Basin.

Scale and Scope

Vulnerability of species and populations to changes induced by global warming was assessed using a scoring system similar to that developed for identifying avian populations at risk by Partners in Flight (Panjabi et al. 2005). A detailed account of the scoring for each species resulted. Scores are adjustable as new information arises. The basic process was as follows:

- Compile information on vertebrate species of the Middle Rio Grande Bosque
- Compile information on projected climate change effects for the Middle Rio Grande Basin
- In consultation with experts, create scores for individual species for each variable
- Create composite scores and prioritize species by vulnerability

The assessment for this case study evaluated the full array of terrestrial vertebrate species inhabiting riparian woodlands along the Middle Rio Grande in New Mexico. The geographical boundaries of the Middle Rio Grande are demarcated as the stretch of the river from Cochiti Dam (at its northernmost edge) downstream 160 miles to San Marcial and Elephant Butte Reservoir, and the Bosque portion of it extends south to San Acacia (Figure C3.2). The Middle Rio Grande Valley includes four New Mexico counties (Sandoval, Bernalillo, Valencia, and Socorro) and six Indian pueblos (Cochiti, Santo Domingo, San Felipe, Santa Ana, Sandia, and Isleta).

Assessment Approach

The system assigns scores from synthesized information related to probability of population declines as related to anticipated changes that directly or indirectly result from climate change. Possible scoring variables are: exposure to natural disturbance (e.g., flooding, wildfire); breeding requirements (e.g., link with seasonal food resources, temperature range, breeding ponds); nonbreeding requirements (e.g., habitat changes, stopover sites); dispersal potential (e.g., geographic barriers, mobility); and exacerbating factors (e.g., specialist species, physiological limitations, competition with invasive species). Scores in each category are assigned to individual species on an ordinal scale from lowest to highest risk. For example, when looking at natural disturbance a species may have a high score if it negatively responds to wildfires, which are predicted to increase. A species may have a low score if it responds positively to disturbances that are expected to increase or if its habitat is not threatened by these sources of disturbance.

The assessment comprises a series of questions that focus around variables or traits believed to reflect the potential impacts of climate change on the ability of individual species to survive and reproduce. Each question is accompanied by a series of potential responses that, in turn, are associated with a simple score of 1 (vulnerable), 0 (neutral or unknown), or −1 (resilience). Variables related to climate change effects on species were identified from four broad categories or factors: habitat, physiology, phenology, and biotic interactions.

In addition, we considered whether traits exhibited three primary functions of good scoring variables for assessment designs (Beissinger et al. 2000): (1) repeatability, (2) relation to quantitative values, and (3) independence from other scoring variables. Our adherence to these criteria, however, was limited because quantitative data currently available for species' response to climate change are rare and inherently imprecise for future projections. A separate score for uncertainly that reflects the quantity and quality of data used to score a species is also included.

Two types of scores are provided for different purposes: categorical scores and overall scores. Overall scores can be used to rank species and identify the most vulnerable or resilient species. Alternatively, overall scores can also be used to categorize species into broad vulnerability levels. Because not all species attributes translate to equal risk from climate change, composite scores allow for prioritization of species vulnerabilities for complex information. Categorical scores can be used to identify specific areas or traits related to vulnerability.

Scores for individual criteria can identify vulnerable and resilient characteristics that could aid in single-species management decisions. Identified areas of vulnerability or resilience and their relative influence can be used to target the most effective management actions (i.e., creation of corridors, land acquisition, captive breeding). In addition, scores can be adjusted and categories added as effects of climate change manifest or threats are identified by new research. Prioritization of species for management will have to additionally consider issues such as current vulnerability, economic feasibility, and regulations. Managers can also incorporate their own knowledge and local issues into considering species prioritization.

Middle Rio Grande Bosque Climate and Habitat Projections

We gathered information on projections for climate and related phenomena as well as disturbances and vegetation types to use for our assessment of the Middle Rio Grande species. To maintain relevance to management planning, we used projections for a period 20 to 50 years in the future. We used ClimateWizard to estimate changes in precipitation and temperatures for the region. We used vegetation projections created by Rehnfeldt et al. (2006) to estimate changes in area and distribution of major vegetation types (Brown et al. 1998). We also outlined specific predictions regarding changes to the riparian and upland habitat of the region using additional information from primary literature sources. Finally, we considered the effect of extreme weather conditions and disturbances, which although more difficult to accurately project, may be more critical to wildlife populations than average changes.

Results

The southwestern United States is expected to experience relatively large temperature increases and specific predictions for the region include an increase in the severity and duration of drought periods, more heat waves, greater variation in precipitation, increased wildfires and insect outbreaks, and increased evapotranspiration and salinization (Easterling 2000; Field et al. 2007; Garfin and Lenart 2007). Perhaps of greatest consequence will be the impact of these changes on southwestern water resources. Specifically, the Southwest is expected to experience a change in seasonal flood regimes, reduced snowpack, and an overall reduction in river and stream flows (Seager et al. 2007).

We predict there will be less open water, shorter duration for ephemeral ponds, and a decline in wetland habitats in the Middle Rio Grande Bosque. These changes will lead to a general loss of riparian vegetation and a narrowing of the riparian corridor. In addition, invasive tamarisk species are likely to increase to the detriment of native cottonwood species. Specific vegetation projections for 2030 showed decreases in Great Basin conifer woodlands (from 10 percent to 1 percent), semi-desert grasslands (38 percent to 25 percent), and a complete loss of Plains grasslands (estimated to comprise 52 percent of the current habitat). Chihuahuan desert scrub was predicted to increase from 0 percent to 74 percent.

Amphibians. Of the nine species of amphibians assessed, five species are found to be vulnerable to climate change. The most vulnerable species was the western chorus frog; three species had

Rick Lewis

neutral scores; and only one, the American bullfrog, appears to be somewhat resilient to climate change effects. Species with water-dependant larval or adult life stages were most vulnerable to future climate projections. The three species of spadefoot toads and the Great Plains toad tended toward lower scores because we predicted that the scrub and grassland habitats used by these species would increase in the Middle Rio Grande region.

Reptiles. Nineteen of 29 reptiles are vulnerable to climate change in the Middle Rio Grande Valley. Five species had high vulnerability scores. The Great Plains skink was the most vulnerable species, while the common kingsnake was the least vulnerable. In general, species that have a specific reliance on riparian habitat show some level of vulnerability to the future expected changes.

Birds. Of the 40 species of birds assessed, 25 species (51 percent) had scores reflecting an overall vulnerability to climate change. The southwestern willow flycatcher was ranked as the most vulnerable and the bank swallow was the least vulnerable. Fourteen species had neutral scores and five species may benefit from future warming trends. The southwestern willow flycatcher (federally listed as endangered), the western yellow-billed cuckoo (a candidate for federal listing), and the common yellowthroat depend on riparian habitat and were among the most vulnerable to potential population declines under future climate projections. The primary habitat of these species is expected to decline, they are sensitive to heat, and they rely on climate-driven cues and/or resource pulses, which are likely to change under future scenarios. The three most resilient species, spotted towhee, house finch, and brown-headed cowbird, are habitat generalists with a good capacity to respond to resource variation.

Most of the bird species we assessed that forage aerially on insects obtained positive overall scores, reflecting vulnerability (cliff swallow, barn swallow, ash-throated flycatcher, northern rough-winged swallow, and bank swallow). An exception to this trend was the eastern bluebird. The three species of woodpeckers had positive scores. Of the four species of raptors, three had

Bruce Stein

positive overall scores; western screech owl was the most vulnerable, followed by Cooper's hawk and great horned owl. By contrast, the score for American kestrel was negative.

Mammals. Thirty-six mammals were assessed for their potential vulnerability to climate change in the study region. The New Mexico meadow jumping mouse appears most vulnerable, while the desert shrew was the least vulnerable to future expected changes. Sixteen percent of the mammal species were vulnerable to climate change effects, 44 percent appear to be only slightly impacted, and 5 percent may benefit from future projected changes. In general, species that appear most at risk given future climate change predictions are animals with a high reliance on riparian areas (the New Mexico meadow jumping mouse and beaver), require dense vegetation or specific vegetation features (the woodrat), or are at risk of mismatch between critical resources and breeding (the hoary bat and black bear). Species not expected to be overly influenced by future climate changes tended to be opportunistic breeders (jackrabbit, desert shrew), with a wide diversity of habitat associations including habitats that are expected to increase in the future.

Uncertainties

All species assessments are prone to errors relating to uncertainties regarding species biology. We found considerable variation in the data available for each species under review. To account for this, we include an uncertainty score. For each of the categories, Habitat, Physiology, Phenology, and Biotic Interaction, we score a species based on the quality and quantity of data that was available for completing the assessment question. These scores are then added at the end of the assessment for an overall uncertainty score. This score is useful not only for estimating the potential for errors in our assumptions regarding species vulnerability but clearly identifies areas that are in need of further monitoring or research efforts.

Assessments of species vulnerability to climate change also have sources of uncertainty specific to the aim of predictions based on future climate scenarios. First, uncertainties exist regarding climate projections produced by climate models. To reduce the impact of individual error attributed to variations in a single model, we used temperature ranges and precipitation estimates that were produced in ensemble models, which average values from several individual models. Vegetation projections and other sources of data regarding future climate conditions are also prone to errors related to methodological procedures. We used most of these tools to gain a perspective on the trends of change rather than define definitive future scenarios. For vegetation projections, we relied less on subtle changes (slight loss or shift in certain habitat types), than on projections of severe change (total loss of habitat). We

also considered predicted loss of vegetation type to be a robust result, whereas estimates of habitat shifts or invasion are more tenuous given the greater unpredictability of potential plant invasion and establishment and the time lag under which these transitions will occur.

Finally, there is uncertainty regarding the realized response of species to climate change. We have attempted to consider a comprehensive suite of traits that allow us to gauge species capacity to tolerate greater variation in resources, higher temperatures, and habitat changes. We have also attempted to account for species interactions within the framework of our tool. Though these efforts have improved the applicability of our tool, it is likely that there remain unpredictable consequences of climate change for species.

Outcomes and Next Steps

We will take these results and identify management (adaptation) strategies and actions for terrestrial species in the Middle Rio Grande Basin. We have also expanded the application of the vulnerability assessment scoring tool to other locations in the American Southwest, including scoring of endangered species on the Coronado National Forest, southeastern Arizona, and on the military bases Fort Huachuca and Barry Goldwater Range. Manuscripts that describe the scoring tool in detail and a Rocky Mountain Research Station General Technical Report that provides the full results of the Middle Rio Grande vulnerability assessment are in review. We are also beginning the process of developing a Web-based version of the tool that will be added to an appropriate Website such as the U.S. Forest Service Climate Change Resource Center Website (http://www.fs.fed.us/ccrc/).

Case Study 4. Vulnerability of Massachusetts Fish and Wildlife Habitats to Climate Change

Purpose and Conservation Objective

This case study describes the use of expert elicitation to assess the vulnerability of habitats at a state-wide scale. Funded by a grant from the Wildlife Conservation Society, Manomet Center for Conservation Sciences began working in early 2008 with the Massachusetts Division of Fisheries and Wildlife and other partners, including The Nature Conservancy, to make the state's existing Wildlife Action Plan "climate-smart." We are presenting the results of

J&K Hollingsworth/USFWS

Lead authors: Hector Galbraith and John O'Leary.