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Using the NatureServe Climate Change Vulnerability Index

A Nevada Case Study

For the Association of Fish and Wildlife Agencies' forthcoming Guidance Document for Climate Change Revisions to State Wildlife Action Plans

NatureServe is a non-profit organization dedicated to providing the scientific basis for effective conservation.

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A Nevada Case Study

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M otivated by the need for a means to rapidly assess the vulnerability of species to climate change, NatureServe initiated a collaborative effort to develop a Climate Change Vulnerability Index. This tool would use distribution and natural history information for a species within a specific geographical area (such as a state) to rapidly estimate relative risk of local extirpation as a result of climate change.

The Index adapts the Williams et al. (2008) framework that separates a species' vulnerability into two main components: exposure to climate change within its range and sensitivity of the species to climate change. Data for these two components take the form of downscaled climate predictions across the range of the species within the assessment area and scoring of the species against 17 factors related to its anticipated climate change sensitivity, such as dispersal ability and habitat specificity. Additional factors addressing indirect exposure to climate change, such as presence in areas likely to be affected by rising sea levels, as well as documented responses to climate change (if available) are also included. These factors are all documented in the scientific literature to be correlates or predictors of vulnerability to climate change. The outcome is one of six possible Index categories: three degrees of "Vulnerable" (Extremely, Highly, Moderately), two degrees of "Not Vulnerable" (Presumed Stable, Increase Likely), and "Insufficient Evidence".

Assessing lists of priority species with this Index provides a means of dividing species into groupings of relative risk to climate change and of identifying key factors causing species to be vulnerable. Used with standard conservation status assessments such as the NatureServe G- and S-rank system (Faber-Langendoen et al. 2009), the Index can help land managers evaluate the likely effectiveness of alternative strategies to promote adaptation of species to climate change as well as select key species to monitor. The results are valuable input for modifications of state wildlife action plans to address climate change.

The Case Study

We applied the Index to a selection of test species from Nevada where the Index is being used in support of efforts to modify the State Wildlife Action Plan ("SWAP") to incorporate climate change. See Tables 1 and 2 for scores for the first 13 species.

Nevada's SWAP was approved in 2006, and although it (like many other states' plans) identified climate change as a stressor to key habitats and species of conservation concern in a few specific areas, it did not address the degree of vulnerability each species may face due to a warming climate. Now that climate change dominates the environmental agenda, Nevada plans to amend its SWAP to incorporate the potential effects of climate change in more detail. The Nevada Department of Wildlife, The Nature Conservancy, Nevada Natural Heritage Program, Lahontan Audubon Society, and Great Basin Bird Observatory have formed a partnership to complete the amendment. The initial focus will be on assessing the vulnerability of Nevada's 263 Conservation Priority species, with the hopes of expanding the application of the Index to plants and other Nevada species.

How It Works

Downscale Climate Information
The Index uses predictions about the magnitude of predicted change in temperature and precipitation across the range of a species within the assessment area in its calculation of relative risk. Although information about predicted climate change can come from any source, a particularly simple solution is Climate Wizard (www.climatewiz. org), a website with downloadable climate data developed as a collaboration among The Nature Conservancy, the University of Washington, and the University of South-

ern Mississippi. Climate Wizard provides data for both historical (1951-2006) and predicted future (2041-2060) climate change in the United States (8-km resolution) and the rest of the world (50-km resolution).

Planning Time Frame
The Index contemplates vulnerability to climate change for a 50-year time frame, a typical cut-off date for predictions made in the International Panel on Climate Change reports (e.g., IPCC 2007) and that used by the current version of Climate Wizard. Users can modify this target year as long as the same year is used as the end date for downscaled climate predictions. Future versions of the Climate Wizard will allow users to request this sort of data based on any user-defined horizon date. If using a time scale significantly different than 2060, the thresholds separating the different Index categories may need adjustment to adequately separate species into different vulnerability categories.

Geographical and Biodiversity Focus
The Index has been developed for assessment areas on the scale of a national park or wildlife refuge to a state. It could be used for a regional analysis in the case of several eastern states, but use for larger regions, especially regions extending outside the USA, has not yet been tested.

For very small assessment areas, most species will occur across the entire area. Climate predictions will not vary much, so the climate exposure factor will be virtually identical for every species assessed. The result will be less variance in the Index scores across species.

The current version of the Index is tailored for use in North America north of Mexico. Use elsewhere may require modification of specific factors relating to local habitat and/or climate features not present in North America. Also, the resolution of downscaled climate predictions may be lower than that currently available for the U.S. In the future, NatureServe may create a version of the Index to assess entire ranges of species if there is sufficient interest.

The biodiversity focus of the Index is at the species level, although assessments of subspecies, populations, or varieties are equally feasible. It is designed for plants and animals, terrestrial and aquatic, and rare and common species, but so far not marine species.

Requirements for Application of the Vulnerability Index
The Index was designed as a fairly quick means of assessing relative risk of species. Zoologists and botanists with broad knowledge of the natural history of the organisms under review can apply the Index rapidly once they are familiar with the criteria. For the Nevada pilot study, NatureServe scientists averaged 30-60 minutes per species to research and enter the necessary data. Information required to complete the Index includes historical and predicted temperature and precipitation data for the assessment area, a map of predicted sea level rise (if applicable), a land use map depicting anthropogenically altered segments of the assessment area, a distribution map of the species, natural history information (e.g., habitat relationships, key relationships with other species), and literature documenting the species' response to climate change or predicting future distribution (if available).

When preparing to apply the Index to a group of species, the required spatial data should be downloaded into a GIS where the species' distribution can be overlayed. The Index guidelines provide step-by-step instructions on how to do this such that anyone with at least an advanced beginner's knowledge of GIS could handle these tasks. The guidelines also suggest websites where the information is freely available, although users can use alternative data sources if they desire.

Ideally, an agency carrying out a project using the Index would assemble a team with a project lead, a GIS technician, and either staff botanists and zoologists or locally-recruited scientists. The project lead would be responsible for coordinating among team members, scheduling the work, recruiting knowledgeable scientists, compiling and interpreting the results, and incorporating the results into wildlife action plans. The scientists can either work independently or in a workshop format. Ideally, someone from the Index development team would train the scientists in the use of the Index at the outset of the project to promote continuity of approach and accuracy in interpretation of the criteria.

Documentation of the sources and data used to evaluate each Index factor is highly recommended. This allows the Index to be used as a repeatable, transparent evaluation tool and also sets the stage for use in monitoring species' vulnerability over time. As our experience and knowledge of the pace of climate change and its specific impacts on species increases, the initial Index assessment can provide an important baseline.

Presentation of the Results
Output from the Index is initially compiled in a table sorted by vulnerability categories. Within categories, species can be sorted by conservation status to further order the severity of the risk (Table 1). Listing the factors that contributed to the vulnerability scores highlights how climate change will have the greatest effect on the species assessed, and can suggest which management actions would be most beneficial (Table 2). There are many other ways to present the results, including graphing the numbers of species in each category and overlapping maps of the most threatened species to highlight areas of greatest threat.

Availability

The Climate Change Vulnerability Index and guidelines for its use can be downloaded from the NatureServe website (www.natureserve.org/climatechange).

References Cited

Faber-Langendoen, D., L. Master, J. Nichols, K. Snow, A. Tomaino, R. Bittman, G. Hammerson, B. Heidel, L. Ramsay, and B. Young. 2009. NatureServe Conservation Status Assessments: Methodology for Assigning Ranks. NatureServe, Arlington, VA. Available at www.natureserve.org/publications/library.jsp#nspubs.

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The NatureServe Network

NatureServe is a non-profit conservation organization whose mission is to provide the scientific basis for effective conservation action. NatureServe represents an international network of biological inventories—known as natural heritage programs or conservation data centers—operating in all 50 U.S. states, Canada, Latin America and the Caribbean. The NatureServe network is the leading source for information about rare and endangered species and threatened ecosystems. Together with these network member programs, we not only collect and manage detailed local information on plants, animals, and ecosystems, but also develop information products, data management tools, and conservation services to help meet local, national and global conservation needs.

Table 1. Vulnerability to climate change of thirteen plant and animal species from Nevada. The species were chosen because of concern that they might either decline or increase and displace other species as a result of climate change. The species are ordered by Index score and then S-rank.

Group	Species	Common Name	Index Score	S-rank	G-rank
Mammal	*Aplodontia rufa*	Mountain beaver	Extremely Vulnerable	S1	G5
Fish	*Rhinichthys osculus oligoporus*	Clover Valley speckled dace	Highly Vulnerable	S1	G5T1
Butterfly	*Limenitis archippus lahontani*	Nevada viceroy	Highly Vulnerable	S1S2	G5T1T2
Mammal	*Ochotona princeps*	American pika	Highly Vulnerable	S2	G5
Mammal	*Sorex palustris*	Water shrew	Highly Vulnerable	S2	G5
Fish	*Oncorhynchus clarkii henshawi*	Lahontan cutthroat trout	Highly Vulnerable	S3	G4T3
Amphibian	*Rana pipiens*	Northern leopard frog	Moderately Vulnerable	S2	G5
Plant	*Draba cusickii var. pedicellata*	Cusick's whitlow-grass	Moderately Vulnerable	S3	G4T3
Bird	*Leucosticte atrata*	Black rosy-finch	Moderately Vulnerable	S3	G4
Plant	*Populus tremuloides*	Quaking aspen	Moderately Vulnerable	SNR	G5
Plant	*Asclepias eastwoodiana*	Eastwood milkweed	Presumed Stable	S2	G2
Reptile	*Phrynosoma platyrhinos*	Desert horned lizard	Presumed Stable	S4	G5
Bird	*Quiscalus mexicanus*	Great-tailed grackle	Increase Likely	S5	G5

Table 2. Factors contributing to vulnerability status of selected Nevada plants and animals. The factors shown are a subset of the factors used in the Index. For more details on the factors, see the Index documentation (www.natureserve.org/climatechange). Species are scored on how a factor affects its vulnerability (GI, Greatly Increase; Inc, Increase; SI, Somewhat Increase; N, Neutral; SD, Somewhat Decrease; Dec, Decrease; U, Unknown). The abbreviations for Index Score refer to the corresponding scores shown in Table 1. For these species, natural dispersal barriers, dispersal ability, and micro-scale precipitation tolerance are the most important factors causing vulnerability to climate change.

Species	Natural barriers	Anthropogenic barriers	Dispersal ability	Macro-scale temperature requirements	Micro-scale temperature requirements	Macro-scale precipitation requirements	Micro-scale precipitation requirements	Dependence on ice/snow	Physical habitat requirement	Diet specialization	Migrations - movements	Genetic variation	Index Score
Aplodontia rufa	Inc	N	Inc	SI	SI	Inc-SI	N	N	N	N	SI	U	**EV**
Rhinichthys osculus oligoporus	N	N	Inc	N	N	GI-Inc	GI	N	N	N	SI	U	**HV**
Limenitis archippus lahontani	N	N	Inc	N	SI	SI	GI	N	N	Inc	SI	U	**HV**
Ochotona princeps	GI-Inc	N	SI	SI-N	N	SI-N	N	N	Inc	N	SI	U	**HV**
Sorex palustris	Inc	N	Inc	N	SI	SI-N	GI-Inc	N	N	N	SI	U	**HV**
Oncorhynchus clarkii henshawi	N	N	N	N	Inc-SI	SI	Inc-SI	N	N	N	Inc	U	**HV**
Rana pipiens	N	N	N	N	SI	SI	GI-Inc	N	N	N	SI	U	**MV**
Draba cusickii var. pedicellata	N	N	Inc	N	SI-N	SI	N	N	SI	N/A	U	U	**MV**
Leucosticte atrata	GI	N	Dec	SI	U	SI	N	SI	Inc-SI	N	SD	U	**MV**
Populus tremuloides	N	N	GI	N-SD	Inc	SI-N	SI	N	N	N/A	U	SD	**MV**
Asclepias eastwoodiana	N	N	SI	N	N	SI	Inc	N	N	N/A	U	U	**PS**
Phrynosoma platyrhinos	N	N	N	N	SD	Inc-SI	N	N	N	SI	SI	U	**PS**
Quiscalus mexicanus	N	SD	Dec	N	N	N	N	N	N	SD	U	U	**IL**