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Abstract

Land managers need a better understanding of factors that contribute to climate-change vulnerability of natural communities in order to formulate adaptation strategies. NatureServe worked with federal, state, and NGO partners in the U.S. and Mexico to conduct CC vulnerability assessments of major upland and aquatic community types from the Mojave and Sonoran deserts. This project piloted a new Habitat Climate Change Vulnerability Index, drawing on data from the BLM Rapid Ecoregional Assessments and other research efforts. Assessments addressed CC sensitivity and ecosystem resilience; the latter derived from analysis of CC indirect effects and adaptive capacities. Then in a workshop setting, field specialists refined the assessments, clarified thinking on CC scenarios and stressors, and documented potential strategies along a continuum from immediate "no regrets" actions to "anticipated" or "wait and watch" actions to monitor. By focusing on major natural community types, pragmatic strategies were identified for application across multiple managed lands.

Executive Summary

The earth's changing climate is forcing reconsideration of strategies for conserving natural resources. Managers need to understand where and when the resources they manage might be vulnerable to climate change. They also need a better understanding of the factors that contribute to that vulnerability. This knowledge is essential to determine which management actions will be suitable over the coming decades.

NatureServe worked with a number of federal, state, and NGO partners in the United States and Mexico to conduct a climate change vulnerability assessment of major natural community types found within the Mojave and Sonoran Deserts. The project focused on ten major upland, riparian, and aquatic community types, including pinyon-juniper woodlands, Joshua tree-blackbrush scrub, creosote-bursage scrub, salt desert scrub, Paloverde-mixed cacti scrub, semi-desert grassland, desert riparian and stream, riparian mesquite bosque, and desert springs. This effort piloted a new Habitat Climate Change Vulnerability Index (HCCVI) approach being developed by NatureServe, as a companion to an existing index for species. The project utilized existing data, much of which had been recently developed through the Bureau of Land Management's rapid ecoregional assessments, or by ongoing research efforts with FWS, NPS, and USGS. Once vulnerability assessments were drafted, an expert workshop was held to review and revise the assessments, and then apply the findings to identify climate change adaptation strategies applicable across managed lands within each ecoregion.

Components of the Climate Change Vulnerability Index for Ecosystems and Habitats (HCCVI)

The HCCVI aims to implement a series of measures addressing climate change sensitivity and ecological resilience for each community type for its distribution within a given ecoregion (in this case, the Mojave vs. Sonoran Desert). Since quantitative estimates may not be feasible for all measures, both numerical index scores (*normalized 0.0-1.0 scores*) and qualitative expert categorizations may be used in the HCCVI. The combined relative scores for **sensitivity** and **resilience** determine the categorical estimate of climate change vulnerability by the year 2060 (i.e., 50 years into the future) for a community type. While the overall index score for each community should be useful for regional and national priority-setting and reporting, the results of these individual analyses should provide insight to local managers for climate change adaptation. Index measures are organized within categories of **direct effects**, **indirect effects,** and **adaptive capacity**. A series of 3-5 measures, each requiring a separate type of analysis, produces sub-scores that are then used to generate an overall score for **sensitivity** (*from direct effects*) vs. **resilience** (*indirect effects + adaptive capacity*).

Direct effects can be addressed through several measures, depending on the natural characteristics of the community type. For example, analysis of downscaled global climate forecasts for temperature and precipitation variables provides an indication of the relative intensity of climate-induced stress. For upland vegetation, climate envelope models can be used to correlate and map current plant community distributions with a suite of key climate variables from a 20th century baseline. Then, the location of that same climate envelope as predicted for 2060 using climate forecasts, provides an indication of the directionality, magnitude, and overlap of geographic shift for species from the community. These can also provide insight about plausible patterns for successional dynamics and transitions across major vegetation on the regional landscape. Dynamic simulations of fire regime or hydrologic regime may be used to forecast trends in the alteration or 'departure' from expected conditions for upland vs. riparian/aquatic communities, respectively.

Indirect effects include trends in ecological integrity. These can indicate the potential for resilience to climate change. Analyses may include spatial models aiming to characterize the degree of landscape fragmentation or other anthropogenic impacts (such as invasive species) in the landscapes supporting a given community type. Dynamic simulations of fire regime or hydrologic regime may be used here, not for forecasting, but instead to characterize the past and current degree alteration or 'departure' from expected conditions for upland vs. riparian communities, respectively.

Adaptive capacity includes inherent characteristics of a natural community that make it more or less resilient to climate change. Attributes can include diversity within groups of species playing key functional roles. It could also include analysis of climate change vulnerability for species that may provide 'keystone' functions in the community. Additionally, the relative breadth of bioclimatic and elevation range that characterizes a communities natural distribution can indicate inherent capacity to cope with climate change.

For the HCCVI, climate-change vulnerability is expressed in four categories, including Very High, High, Moderate, and Low vulnerability. Therefore, the index ratings are quite general, but this is because predictive uncertainty is often high, and our overall intent is a generalized indication of vulnerability. This is analogous to a scoring of "endangered" or "threatened" for a given species, but here focused specifically on climate change vulnerability, and applied to community types.

This pilot analysis resulted in six type/ecoregion combinations being categorized high for climate-change vulnerability. These included Mojave Mid-Elevation [Joshua tree-Black brush] Desert Scrub (Mojave Desert), North American Warm Desert Riparian Woodland and Stream (Mojave and Sonoran deserts), North American Warm Desert Mesquite Bosque (Mojave and Sonoran deserts), Sonora-Mojave Creosotebush-White Bursage Desert Scrub (Sonoran Desert). All other types were categorized as moderate for climate-change vulnerability. No types from this pilot analysis were categorized as either very high or low for climate-change vulnerability.

Given the **direct effects** measures aiming to gauge climate-change sensitivity, all but three types in the analysis resulted in the high-sensitivity category. The three types found to be in the moderate sensitivity category included Sonora-Mojave Creosotebush-White Bursage Desert Scrub (Mojave Desert), Sonora-Mojave Mixed Salt Desert Scrub (Mojave Desert), and Apacherian-Chihuahuan Semi-Desert Grassland (Sonoran Desert). Climate envelope shift and dynamic process forecast scores determined these results.

Indirect effects scores fell between a low resilience score of 0.46 (North American Warm Desert Riparian Woodland and Shrubland (Mojave) and a high resilience score of 0.84 (North American Warm Desert Active and Stabilized Dunes (Sonoran). Eleven of 16 type/ecoregion combinations fell within the medium resilience range for their average scores. On the whole, average resilience scores tended to be pulled lower by either low scores for current landscape condition, current invasive species effects, current dynamic regime departure, or some combination of these three.

Adaptive capacity scores tended to contribute to higher overall resilience scores, with their averages ranging from a medium resilience score of 0.56 (North American Warm Desert Active and Stabilized Dunes- Sonoran) to a high resilience score of 0.83 (Desert Springs and Seeps – Mojave and Sonoran). On the whole, average resilience scores tended to be pulled lower by either low diversity within identified functional species groups (e.g., desert springs, mesquite bosque, mixed salt desert scrub), keystone species vulnerability (e.g., creosote-bursage scrub, semi-desert grassland), or where types occur across a relatively narrow elevation range (6 types).

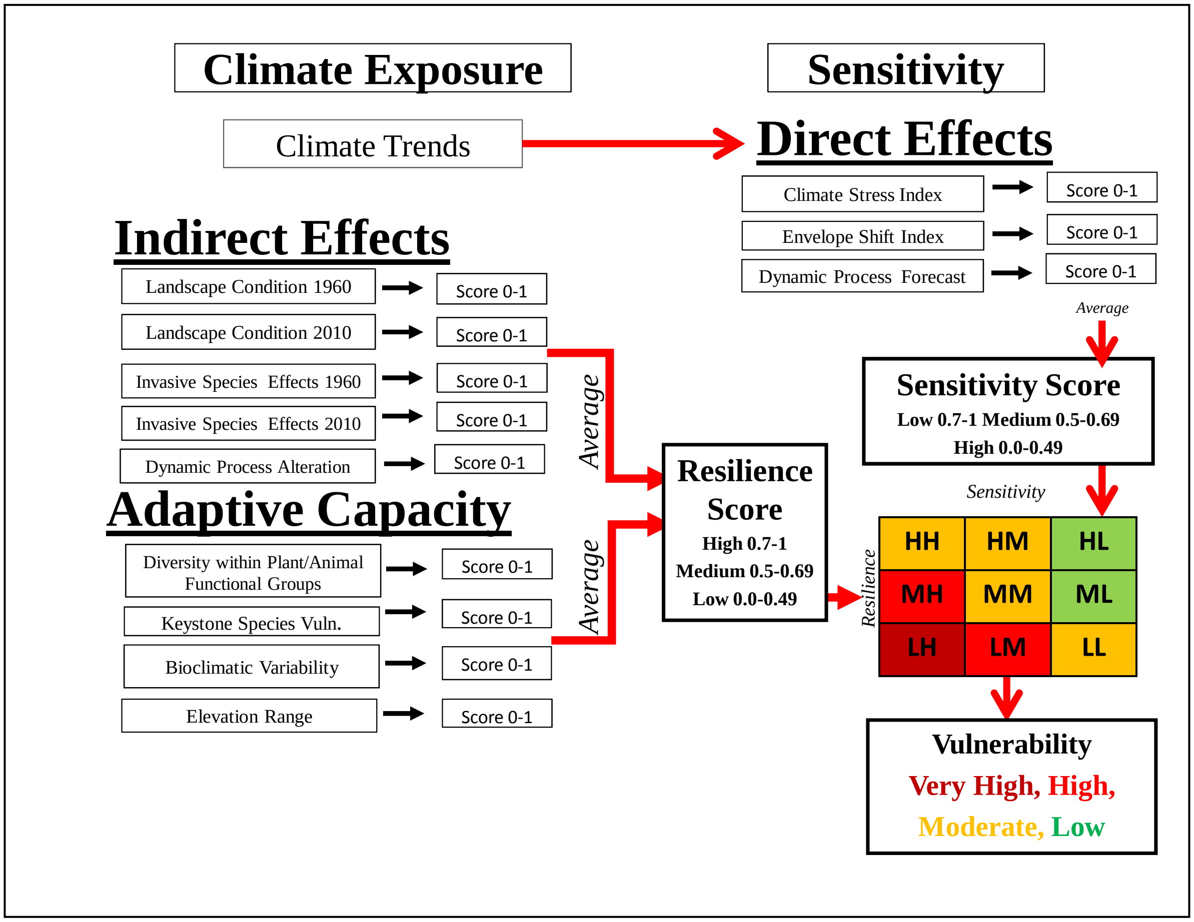
Overall resilience scores ranged from medium (8 types) to high (8 types); but these scores all fell into a narrow range between 0.63 and 0.74. A moderate climate-change vulnerability assessment resulted from the combination of 1) high sensitivity with high resilience (7 types), medium sensitivity and medium resilience (2 types) and 3) medium sensitivity and high resilience (1 type) combinations for a given community type.

Climate Change Adaptation includes actions that enable species, systems and human communities to better cope with or adjust to changing conditions. Some have categorized adaptation strategies into three areas, including resistance, resilience, and facilitated transformation. *Resistance* strategies aim to prevent the direct effects of climate change. *Resilience* strategies aim to secure the capacity to cope with the effects of climate change by ensuring that critical ecological process – as currently understood – are restored to a high level of function or integrity. *Facilitated Transformation* strategies anticipate the nature of climate-change induced transitions and, working with these anticipated trends, include actions that facilitate transitions that are congruent with future climate conditions, while minimizing ecological disruption.

There is also critical temporal dimension to climate-change adaptation. While traditional natural resource management has been ‘retrospective’ – utilizing knowledge of past and current conditions to inform today’s management actions – planners are increasingly required to rigorously forecast future conditions. It is no longer sufficient to assess “how are we doing?” and then decide what actions should be prioritized for the upcoming 5-15 year management plan. One must now ask “where are we going, and by when?” and then translate that knowledge back into actions to take in the near-term, or medium-term, or those to monitor and anticipate taking over longer planning horizons.

The link between climate change vulnerability assessment and adaptation strategies was facilitated in this effort by a) selection of major natural communities as our units of analysis, and b) organizing local expert review within each ecoregion, where decisions across jurisdiction pertain to many of the same community types. The latter step was facilitated by a 2-day expert workshop. Workshop participants reviewed and refined each vulnerability assessment, and then most readily identified components of indirect effects scores (e.g., landscape condition, invasive species, dynamic process alteration) as forming the focus of many “no regrets” adaptation strategies that could be pursued by managers. In most cased, these factors relate to the stressors that are best known and are currently being addressed within managed areas. Where indirect effects stressors were less well known, and/or interactions with climate change were less clear, strategies tended to be categorized as “anticipated actions” within the 5-15 year timeframe, where additional information will be required to move forward, but participants could foresee their implementation.

Direct effects, such as climate stress and climate envelope shifts, challenged workshop participants to identify novel climate-change stressors for each community type, such as effects of heat stress or changes in seasonality of precipitation and their potential effects on functional species groups, such as pollinators. Given the limits to current knowledge in these areas, the strategies identified tended to fall in the “wait and watch” category, where research questions are specified and investment will be required over upcoming decades in order to determine appropriate management actions.



Flow Chart for Habitat Climate Change Vulnerability Index (HCCVI)