STRATEGIES for INTEGRATING
CLIMATE ADAPTATION MODELS
into RESOURCE PLANNING

Yale SCHOOL OF FORESTRY &
ENVIRONMENTAL STUDIES
AS OUR CLIMATE CHANGES, many plant and animal species are reacting by shifting their geographic ranges. As a result, resource managers* are now faced with the challenge of developing and implementing strategies that will support wildlife to adapt to climate change.

The large number and diversity of models and data that can be applied to climate-impact analyses and adaptation strategies can often be confusing. Recognizing a need for clarity within this field, the Yale School of Forestry & Environmental Studies convened a working group of the nation’s leading conservation biologists, modelers and policymakers to develop guidance for integrating climate-change adaptation strategies into the context of natural-resource planning and policymaking.
The Yale Framework

The product of this working group—The Yale Framework—assists resource managers in selecting the assessment and modeling strategies that are most relevant to their specific needs. The Yale Science Panel seeks to provide consistency in this field by guiding choices among the many tools, data and methods, which planners may use to implement their adaptation approaches in the face of a changing climate.

In its most basic sense, the Yale Framework recommends that planners consider an optimal combination of six adaptation approaches at three distinct levels of ecological organization. The Framework offers insights on how to establish a baseline of current environmental conditions, identify which ecological features will likely be most vulnerable to climate change, and visualize the future needs of the most vulnerable species, ecosystems and landscapes.

Rather than supplanting existing techniques, the Yale Framework provides simplified and flexible advice on models and data, and presents a list of commonly used datasets that can be helpful to planners. To achieve this purpose, the Framework provides a structured menu of options that assist resource managers in determining the best possible approach to conservation, as opposed to offering a prescriptive approach to natural resource management.

How the Yale Framework helps the policymaker

• It organizes the reasoning behind the use of specific assessment approaches.
• It helps build a better understanding of the types of questions a model can credibly address.
• It ensures greater transparency with a strong foundation of data.
• It focuses assessments on the appropriate scale and planning use.
• It can serve as a tool for policymakers to evaluate the models behind proposed land use plans.

* Because this document is intended for a broad audience, which includes federal, state and local decision-makers, terms such as policymaker, resource manager, planner or user, are intended to be general in nature.
Strategies for integrating climate adaptation into resource planning

Specifically, the Yale Framework details the state of knowledge regarding different approaches and the tradeoffs of using one approach or dataset over another. Most of the approaches rely, to a varying degree, on using quantitative models or decision-support tools. To help ensure that planners and practitioners are able to apply these models and tools successfully, the Yale Science Panel has developed a Web portal that provides information helping users understand how a particular model works, what the model is designed to depict and the model’s underlying assumptions. To most effectively use the wide variety of datasets that are made available to implement the Yale Framework, information is provided on data availability, source, geographic coverage and minimum mapping units.

The Yale Science Panel recommends specific strategies and relevant datasets across six broad adaptation objectives. The six basic approaches to adaptation drive the following questions that models and a decision-support tool can help answer:

1. What are the current patterns of biodiversity and how can they be conserved? This constitutes the baseline of current assets that will help ensure the highest-possible resilience to change.

2. What will the future patterns of biodiversity look like across a varied landscape? Models can be used to predict the manner in which climate change fundamentally influences the distribution of species, interactions among species and the underlying ecological processes that support them.

3. What is the best way to maintain ecological processes? Changes in an ecosystem’s processes can influence its ability to withstand and/or adapt to environmental change. Understanding these potential impacts is necessary for finding the right strategies to preserve ecological function.

4. How can ecological connectivity be best maintained or restored? Species may respond to changes in their habitats by shifting their geographic ranges, either longitudinally or by elevation. Maintaining and restoring landscape connectivity can help species adapt to a changing climate.

5. What areas are predicted to have relatively stable climate over the long term? When climate-related stressors change species’ habitats so quickly that migration is impossible, those species may benefit from the availability of uniquely situated areas within a specific habitat that offer relatively stable environmental conditions. It is important to identify these safe havens—also known as refugia.

<table>
<thead>
<tr>
<th>Adaptation Approaches:</th>
<th>Levels of Ecological Organization</th>
</tr>
</thead>
<tbody>
<tr>
<td>Protect current patterns of biodiversity (baseline)</td>
<td>Landscapes</td>
</tr>
<tr>
<td>Project future patterns of biodiversity</td>
<td>Ecosystems</td>
</tr>
<tr>
<td>Maintain ecological processes</td>
<td>Species &amp; Populations</td>
</tr>
<tr>
<td>Maintain and restore ecological connectivity</td>
<td></td>
</tr>
<tr>
<td>Protect climate refugia</td>
<td></td>
</tr>
<tr>
<td>Protect the ecological stage (enduring features)</td>
<td></td>
</tr>
</tbody>
</table>
6. What are the on-the-ground environmental conditions best suited to provide habitats for the native plant and animal species of a region to persist in a climate-change era? Recent research suggests that conserving the underlying “ecological stage” of a region (its geological, soil and topographic features) is a solid approach for maintaining biodiversity under different climate-impact scenarios.

The Yale Framework was constructed so that these six adaptation approaches can be applied across three separate scales of ecological organization: Landscapes; Ecosystems; and Species and Populations. With geographic extent, planning goals and audience in mind, one can use the Yale Framework to identify the types of analyses and datasets in accordance with the needs of an assessment.

The Yale Framework recommends a focus on both species and ecosystems, because it encourages consideration of the broader ecological context. This is important because political jurisdictions are often embedded within larger ecological regions on varying landscapes, and climate change is a phenomenon that transcends current boundaries. And notably, in addition to being useful as an assessment guide, decision-makers can use the principles set forth in the framework to evaluate the validity of the ecological components within an existing climate-adaptation assessment.

What the policymaker should know about models:
Models can be useful in understanding future conditions, but poorly devised or misused models can confuse planning processes and cast doubts on modeling as a bona fide planning tool. Consequently, policymakers and resource managers should keep the following in mind:

- Use models at their intended scale: Regional, Ecosystem or Species.
- Clearly define project objectives in order to create a useful and accurate model.
- Define the biological processes, and map the appropriate model to the process.
- Understand generally how a model works, what it depicts and the assumptions behind it. This helps ensure that the selected model captures the biology of interest.
- Understand that there is uncertainty in all modeling approaches, but don’t let that cripple the planning process. Work to identify the uncertainty. Decisions can be always modified as more information becomes available.
- Consider selecting multiple models and analyzing the different results. Each model will give you some insight into the problem. Modeling is a process, not an end in itself.
Teams are currently testing the Yale Framework across the country. These pilot projects are addressing a variety of climate- and adaptation-related issues, including renewable energy siting, identification of migration corridors and other critical habitats, and broad-scale land use change. Results of these pilot efforts will be used to revise and strengthen the Yale Framework, which will broaden its usefulness across multiple planning sectors. The Yale Science Panel will use the pilot projects to improve the Framework, and a revised version of will be available by May 2012.

6 questions to ask when considering a model:

Models can be very useful when understanding future trends. Just don’t leave it up to the experts. It is necessary for you to understand the models and the resulting maps in order to make an informed decision. Questions that might help you in your decision-making include:

- If a model is used, inquire how it works. You should have a general understanding of it. Models are not fact. Does the model make biological sense to you?
- How did the modeler obtain the parameters and decision rules for the models, and how did they validate that their model was correct?
- What areas of the models are most uncertain?
- In a connectivity corridor model, because not all corridors are suitable for all species, what species are the corridors for? How was it determined which areas should be connected and how many corridors there should be?
- The colors of a map correspond to a category or a number. When terms such as *most threatened* and *most ecologically significant*, etc., are used, ask what they mean and how these concepts were boiled down to a single number or color on a map. What do the numbers mean relative to the biology of the species?
- What is the scale of the data the model is built on? What is the geographic coverage or the extent of the study area, and how have cross-boundary issues (e.g. across state lines) been addressed? Does the scale and quality of the input data allow the model to enhance understanding of the desired biology?

Additional information

Current Projects Applying the Yale Framework

The Geos Institute will apply elements of the Yale Framework to Pacific coastal rainforests. Objectives are to compare baseline-to-future climate scenarios, identify key processes likely to shift in response to climate change, and identify relatively stable climatic areas that might function as microrefugia. Climate change models will be used to project potential shifts at regional, subregional, focal species and microsite levels. The results will have application to forest planning, landscape conservation cooperatives of the U.S. Fish and Wildlife Service and high-profile species.

NatureServe will test several aspects of the Yale Framework by integrating and or downscaling
assessment results from two BLM Rapid Ecoregional Assessments (REAs) with core recommendations from the Framework along the ecotone between the Central Great Basin and Mojave Desert Ecoregions. Results will be used to develop adaptation strategies for integration into state and field-office planning by BLM Nevada to manage public land in a scientifically defensible and effective way under rapid climate-change conditions.

EcoAdapt will use the Yale Framework to provide an integrated assessment of spatially explicit adaptation opportunities that address and link watershed function from terrestrial, to freshwater, to coastal systems in the Puget Sound Basin. The goal is to support climate-savvy, integrated watershed management across ecosystem types.

Florida Natural Areas Inventory/Florida State University will incorporate a key element identified in the Yale Framework that is currently missing from Florida conservation planning—protecting the ecological stage. This project will evaluate habitat heterogeneity and available geophysical data to define the ecological stage in areas likely to be affected by sea-level rise by the end of this century. The resulting conservation value layer will be further refined to consider connectivity, habitat fragmentation and ecological integrity, with results incorporated into ongoing statewide conservation planning efforts.

The Conservation Biology Institute has developed a project that compares and integrates alternative climate-change analytical approaches at several spatial resolutions to address climate impacts on two rare forest-dependent carnivores—fisher (Martes pennanti) and marten (M. americana [caurina]). The integrated results on future habitat suitability for these two species will be used to inform how to best apply existing climate models and tools to support wildlife conservation, and will also inform ongoing forest policy and management throughout the region.

The University of Washington will explore the concept of protecting a diversity of abiotic conditions (land facets) as a means of protecting biodiversity in a changing climate. Research will be conducted across 14 ecoregions in the northwestern United States and will result in mapped land facets that feed into an ongoing climate-change vulnerability assessment that serves three state wildlife agencies, the National Park Service and a regional conservation planning effort lead by The Nature Conservancy.
YALE SCIENCE PANEL MEMBERS

- **Paul Beier**, Professor of Conservation Biology and Wildlife Ecology, Northern Arizona University School of Forestry
- **Douglas (Sandy) Boyce**, National Wildlife Ecologist, USDA Forest Service
- **Jason Bulluck**, National Heritage Information Manager, Virginia Department of Conservation and Recreation
- **Craig Groves**, Director of the Conservation Methods Team, The Nature Conservancy
- **Kevin M. Johnston**, Product Engineer, Environmental Systems Research Institute
- **Mary Klein**, President & CEO, NatureServe
- **Gary Knight**, Director, Florida Natural Areas Inventory
- **Joshua Lawler**, Associate Professor, University of Washington School of Forest Resources
- **Kit Muller**, Strategic Planner, Bureau of Land Management
- **John Pierce**, Chief Wildlife Scientist, Washington Department of Fish and Wildlife
- **James Strittholt**, President and Executive Director, Conservation Biology Institute
- **David M. Theobald**, Research Scientist and Assistant Professor, Colorado State University Department of Fish, Wildlife, and Conservation Biology
- **Stephen C. Trombulak**, Professor of Biology and Environmental Studies, Middlebury College

The development of the Yale Framework is supported by The Doris Duke Charitable Foundation, Kresge Foundation and Wilburforce Foundation. The current Yale Framework and additional supporting project documents are available to the public and can be obtained by contacting:

**Oswald Schmitz**
Oastler Professor of Population and Community Ecology
Yale School of Forestry and Environmental Studies
370 Prospect Street, New Haven, CT 06511
Ph: (203) 432-5110
Email: oswald.schmitz@yale.edu

**Will Singleton**
Principal
Singleton Strategies, LLC
3505 Ringsby Court, #110, Denver CO 80216-4920
Ph: (303) 284-6266
Email: will@singletonstrategies.com