Making the Most of What’s in the Kitchen Cupboard … the National Climate Change and Wildlife Science

K. Bruce Jones
National Climate Change & Wildlife Science Center
US Geological Survey

2 November 2011
Presentation Highlights

• Overview of the National Climate Change and Wildlife Science Center
• Examples of ongoing research and development
• My research interests
Secretarial Order 3289

Addressing the Impacts of Climate Change on America's Water, Land, and Other Natural and Cultural Resources (9/14/09)

... the United States Geological Survey (USGS) has been developing regional science centers ... currently known as "regional hubs" of the National Climate Change and Wildlife Science Center...

The Climate Change & Energy Response Council will work with USGS and other Department bureaus to rename these regional science centers as Regional Climate Science Centers and broaden their mandate ...
Mission

Provide natural resource managers with the tools and information they need to develop and execute management strategies that address the impacts of climate change on fish, wildlife, and their habitats.

Focus on climate change adaption & impacts

“Adjustment in natural or human systems in response to actual or expected climatic change effects, to moderate harm or exploit beneficial opportunities"
Climate Science Centers
A New Paradigm

• Linking Physical, Biological, and Social Science
• Scenario/Forecasts of Future Possibilities
• Link Research, Modeling, Synthesis, and Monitoring in a Landscape/System Perspective
• Science Collaboration/Resource Management Collaboration
• Stakeholders set priorities/Provide Review & Feedback
• Share Data and Information
• University/Federal Blend
  – USGS Center Directors (hiring in progress)
• Approach takes advantage of existing models, data, infrastructure and outreach
USGS recognizes that if we expect our science to be responsive to societal needs, we must communicate effectively with those who use the products of our global change science program.

CSCs and Landscape Conservation Cooperatives (LCCs) will play a key role in science collaboration and communication within the natural resource management community.
Regional Centers (CSCs)

- Alaska (U of Alaska)
- Northwest (Oregon State, U of Washington, U of Idaho)
- Southeast (North Carolina State U)
- North Central (Colorado State U)
- Southwest (U of Arizona, Desert Research Institute, Northern Arizona U)
- Pacific (U of Hawaii)
- Northeast (U Mass consortium)
- South Central (U of Oklahoma consortium)
- Substantial leveraging of University capacity
- All Centers (except Alaska) established via competitive process
- All Centers have considerable existing outreach to stakeholders
NCCWSC National & Regional Organization

For more information:
http://www.doi.gov/whatwedo/climate/strategy/index.cfm
1. Forecast fish and wildlife population and habitat changes in response to climate change.

2. Assess the vulnerability and risk of species and habitats to climate change.

3. Link models of physical climate change (such as temperature and precipitation) with models that predict ecological, habitat, and population responses.

4. Develop standardized approaches to monitoring and help link existing monitoring efforts to climate and ecological or biological response models.

5. Expand to multiple environmental values and ecosystem services
Approximation of locations of NCCWSC funded projects (from FY09 RFP and subsequent add-ons)

- Nation’s Fish Habitat – Glacial lakes focus site
- Freshwater mussels (St Croix River)
- Missouri River sturgeon
- Great Lakes Fisheries
- Nation’s Fish Habitat – Rocky Mtn focus site
- Western Salmonids
- Prairie Pothole Region
- Freshwater mussels (Atlantic slope)
- Nation’s Fish Habitat – Appalachian focus site
- Florida biodiversity - downscaling
- Florida biodiversity – Suwanee and Everglads focal areas
- Bioclimate visualization tool
- Approximation of locations of NCCWSC funded projects (from FY09 RFP and subsequent add-ons)
- Pacific NW ecosystems downscaling
- Northwest estuarine habitats
- Aspen vulnerability in Great Basin
- Mammals mediating alpine vegetation
- SF Bay Wetlands
- Yosemite Toad downscaling CA
- Arid SW wildlife
- Island sea level rise
- Arctic and subarctic avifauna
- Melting glaciers and coastal ecosystems
- Texas surface waters
- Lower Mississippi
- Florida biodiversity – Suwanee and Everglads focal areas
- Bioclimate visualization tool
- National downscaled model
Research and Development
Downscaling Climate Projections

Simulating sub-grid-scale climate based on output from global models

**STATISTICAL DOWNSCALING**

- From the individual farmer’s field to grids as fine as <1km²
- Limited by the resolution of digital topographical maps & availability of observational data

**DYNAMIC DOWNSCALING**

- From 50km² down to ~10km²
- Grids must currently be larger than ~2-5km² due to our limited understanding & parameterization of small-scale physical processes and limits on computing power

By developing a statistical relationship between local climate variables and global model predictors

By explicit solving of process-based physical dynamics of the regional climate system

Downscaling to individual point locations or high-resolution grids for impact analyses

(agriculture, ecosystems, watersheds, urban air pollution & health)
The velocity of climate change

The ranges of plants and animals are moving in response to recent changes in climate. As temperatures rise, ecosystems with ‘nowhere to go’, such as mountains, are considered more threatened. However, species survival may depend as much on keeping pace with moving climates as the climate's ultimate persistence. Here, we present a new index of the velocity of temperature change (km yr⁻¹), derived from spatial gradients (°C km⁻¹) and multimodel ensemble forecasts of rates of temperature increase (°C yr⁻¹) in the 21st century. This index represents the instantaneous local velocity along Earth’s surface needed to maintain constant temperatures, and has a global mean of 0.42 km yr⁻¹ (A1B emission scenario). Due to topographic effects, the velocity of temperature change is lowest in mountainous biomes such as tropical and subtropical coniferous forests (0.08 km yr⁻¹), temperate coniferous forest, and montane grasslands. Velocities are highest in flooded grasslands (1.26 km yr⁻¹), mangroves, and deserts. High velocities suggest that the climates of only 8% of global protected areas have residence times exceeding 100 years. Small protected areas exacerbate the problem in Mediterranean-type and temperate coniferous forest biomes. Large protected areas may mitigate the problem in desert biomes. These results suggest management strategies for minimizing biodiversity loss from climate change. Montane landscapes may effectively shelter many species into the next century. Elsewhere, reduced emissions, a much expanded network of protected areas, or efforts to increase species movement may be necessary.

As climate changes in this century, the current distribution of climatic conditions will be rearranged on the globe; some climates will disappear entirely, and novel (no-analog) climates are expected in wide regions. For species to survive, the persistence of suitable climates is not sufficient. Species must also keep pace with climates as they move. To summarize the speed at which climate is changing, we compute the instantaneous horizontal velocity of temperature change (Fig. 1e) derived from the ratio of temporal (Fig. 1d) and spatial (Fig. 1c) gradients of mean annual near-surface temperature (Fig. 1b) (°C yr⁻¹ + °C km⁻¹ = km yr⁻¹). As exemplified by California, the spatial gradient of temperature change is greatest on mountain
Response Models and Monitoring
Methods for modeling species responses to climate change

Figure 1: Range predictions for *Sceloporus undulatus* in current climates (light gray) and predicted range expansions following a uniform 3 °C warming increase (dark gray). Localities (o) and the atlas range polygon are shown.
Erosion of Lizard Diversity by Climate Change and Altered Thermal Niches

Barry Sinervo,1,15* Fausto Méndez-de-la-Cruz,2 Donald B. Miles,3,15 Benoit Heulin,4 Elizabeth Bastiaans,1 Maricela Villagrán-Santa Cruz,5 Rafael Lara-Resendiz,2 Norberto Martínez-Méndez,2 Martha Lucia Calderón-Espinosa,6 Rubi Nelsi Meza-Lázaro,2 Héctor Gadsden,7 Luciano Javier Avila,8 Mariana Morando,8 Ignacio J. De la Riva,9 Pedro Victoriano Sepulveda,10 Carlos Frederico Duarte Rocha,11 Nora Ibargüengoytía,12 César Aguilar Puntriano,13 Manuel Massot,14 Virginie Lepetz,15† Tuula A. Oksanen,16 David G. Chapple,17 Aaron M. Bauer,18 William R. Branch,19 Jean Clobert,15 Jack W. Sites Jr.20

It is predicted that climate change will cause species extinctions and distributional shifts in coming decades, but data to validate these predictions are relatively scarce. Here, we compare recent and historical surveys for 48 Mexican lizard species at 200 sites. Since 1975, 12% of local populations have gone extinct. We verified physiological models of extinction risk with observed local extinctions and extended projections worldwide. Since 1975, we estimate that 4% of local populations have gone extinct worldwide, but by 2080 local extinctions are projected to reach 39% worldwide, and species extinctions may reach 20%. Global extinction projections were validated with local extinctions observed from 1975 to 2009 for regional biotas on four other continents, suggesting that lizards have already crossed a threshold for extinctions caused by climate change.

Global climate change affects organisms in all biomes and ecosystems. Two natural compensatory responses are possible. Given enough time and dispersal, species may shift to more favorable thermal environments, or they may adjust to new environments by behavioral plasticity, physiological plasticity, or adaptation. Alternatively, failure to adjust or adapt culminates in demographic collapse and extinction. Despite accumulating evidence of contemporary climate change affecting species (1), but not extinctions (9). Hence, there is still much uncertainty regarding the expected magnitude of extinctions resulting from climate change (10).

Empirical validation of global extinction forecasts requires three forms of evidence. First, actual extinctions should be linked to macroclimate and validated to biophysical thermal causes arising from microclimate (11). Second, the pace of climate change should compromise thermal adaptation (10), such that evolutionary

Although Sceloporus lizards are herbivores that bask and require solar radiation to maintain physiologically active body temperatures (14, 15), activity in hot weather may result in critical thermal maxima (CTmax) exceeding CTmax, the critical thermal maxima, leading to death. Lizards retreat to cool sites rather than risk death by overheating. Extreme heat stress limits foraging, constraining costly metabolic expenditures like growth, maintenance, and reproduction by undermining population growth. Warmer temperatures can raise extinction risk. Lizards could cope with higher Tb, but this brings them closer to their thermal maximum, which increases risk of overheating. The extinction risk may increase because of other thermal limitations. For example, viviparity, which allows for a thermal adaptation to cold climates, may elevate extinction risk because it can compromise embryonic development in utero (17).

We analyzed rate of change in maximum temperature T(max) at 99 Mexican local extinctions and constructed climate surfaces (fig. S1, 1973 to 2008; fig. S1). Rate of change in T(max) was greatest for winter-spring (May; fig. S1 and table S3A) and increased significantly in northern and central Mexico and to a lesser extent in southern Mexico. We found a strong correlation between rate of change in T(max) during the 40 years and the rate of change in the rate of change in local extinctions (fig. S2 and text).

Many viviparous species in México are found to high elevation “islands” with...
An Important Need: Making response models more dynamic!
USA National Phenology Network

The USA National Phenology Network brings together citizen scientists, government agencies, non-profit groups, educators and students of all ages to monitor the impacts of climate change on plants and animals in the United States. The network harnesses the power of people and the internet to collect and share information, providing researchers with far more data than they could collect alone. Learn more about us
Study of the timing of recurring biological phases, the causes of their timing with regard to biotic and abiotic forces, and the interrelation among phases of same or different species.

*Phenophase*—budbreak, unfolding of first leaf, flowering, fruiting, turning of leaves, animal migration, emergence, growth stages, breeding, nesting, hibernation, etc.
Spring Index based on Simulated First Leaf Date: Slope from 1961-2000

Slope

-0.3
-0.3 to 0
0 to 0.3
> 0.3

Adjusted R-square = 0.362 (0.307)
Slope of reg. line = -0.119 (-0.111)
If lilacs bloom before ~May 20...
Interactions Between Climate Change and Land-use
Land Performance Monitoring and Assessment
Modeling Expected Performance

Modeled GSN = f(site potential, climate)

250m MODIS NDVI

Growing Season NDVI varies by land cover type

Winter Precipitation
Spring Precipitation
Early Summer Precipitation
Late Summer Precipitation
Fall Precipitation
Winter Max Temperature
Spring Max Temperature

Long-term Mean AVHRR TIN
Land Cover
Compound Terrain Index
Slope
Aspect
STATSGO Soil Data
The Model Seeks to Account for Climate/Site Variations and Reveal Management Effects

Performance Anomalies have a significantly different GSN than Expected (modeled GSN)
Ecosystem Performance in Alaska

2004 Yukon Basin Performance Anomalies

Performance = difference between Actual and Expected Performance

Wylie et al. 2008
Vulnerability Assessments
Scanning the Conservation Horizon
A Guide to Climate Change Vulnerability Assessment
Vulnerability Assessment Workgroup Members

This guidance document is a product of an expert workgroup on climate change vulnerability assessment convened by the National Wildlife Federation in collaboration with the U.S. Fish and Wildlife Service.

Naomi Edelson, National Wildlife Federation (Chair)
Nancy Green, U.S. Fish and Wildlife Service (Co-Chair)
Rocky Beach, Washington Department of Fish and Wildlife
Molly Cross, Wildlife Conservation Society
Carolyn Enquist, The Nature Conservancy
Deborah Finch, U.S. Forest Service
Hector Galbraith, Manomet Center for Conservation Sciences
Evan Girvetz, The Nature Conservancy
Patty Glick, National Wildlife Federation
John Gross, National Park Service
Katharine Hayhoe, Texas Tech University; ATMOS Research and Consulting
Jennie Hoffman, EcoAdapt
Doug Inkley, National Wildlife Federation
Bruce Jones, U.S. Geological Survey
Linda Joyce, U.S. Forest Service
Josh Lawler, University of Washington
Dennis Ojima, The Heinz Center for Science, Economics, and the Environment
John O’Leary, Massachusetts Division of Fisheries and Wildlife
Bruce Stein, National Wildlife Federation
Bruce Young, NatureServe
Exposure

Potential Impact

Vulnerability

Sensitivity

Adaptive Capacity
OVERARCHING CONSERVATION GOAL(S)

1. Identify Conservation Target(s)
2. Assess Vulnerability to Climate Change
3. Identify Management Options
4. Implement Management Options

Monitor, Review, Revise

- Species
- Habitats
- Ecosystems

- Sensitivity
- Exposure
- Adaptive Capacity

- Changes in Policy
- Changes in Practice
- Institutional Changes

- Reduce Sensitivity
- Reduce Exposure
- Increase Adaptive Capacity
Scenario Analysis and Planning
Scenario Analysis

- Scenario-based
  - Stakeholders define potential scenarios
  - Models of change in important biophysical conditions and drivers (economic, population growth, transportation networks)
- Base biophysical conditions that don’t change (biophysical characterizations/sensitivities)
- Models relate conditions/species occurrences to important drivers that change based on scenarios
- Goal is to develop decision tools and web-based applications that help reduce vulnerability and risk
- Treat-mill test
Trajectories of Landscape Change in the Willamette Basin

Pre-EuroAmerican Settlement

Circa 1990

Conservation 2050

Plan Trend 2050

Development 2050

Baker et al. 2004
Alternative Futures Analysis Process

Scenario Development:
- Current Conditions
- Historical Change
- Ecological Boundaries
- Demographic and Planning Trends

Effects:
- Terrestrial Vertebrate Biodiversity
- Stream Condition (Fish, Invertebrates)
- River Condition (Habitat Quality)
- Water Uses: Socio-economic Implications

Synthesis Products:

3 Alternative Future Landscapes:
- Development 2050
- Plan Trend 2050
- Conservation 2050

Models and Indicators:
- Willamette Valley Livability Forum
- Willamette Restoration Initiative
GENERAL
1. No buildings in floodplain
2. Well-defined neighborhoods
3. Honor historic town
4. New neighborhoods on NS-EW axis for solar access
5. Forested backdrop to SW
6. Windbreak forest at N
7. Ranch development planned to retain contiguous open range.
TOWN PLAN
1. Central activity space with attractive people-spaces.
2. Integrate school-community
3. Enable school to evolve and develop to meet educational needs.
4. Narrow streets to reduce paving and runoff.
5. Grid block pattern to provide multiple routes through town.
7. Well-defined urban boundary within existing agricultural landscape.
8. Retain character of the agricultural landscape.
9. Use landscaping to screen large buildings.
BUILD COMMUNITY
1. Congregate commercial, institutional, and public activities in one place that joins the town and agricultural community.
2. Locate these activities where water backdrop attracts people
3. Contain community within walkable distance to this core area.
4. Provide common parking area for most activities.
Adaptation
Climate Change Adaptation to be Featured at March Workshop

To date, most discussions concerning climate change have focused on the role of mitigation or ways to limit the potential scale of change. However, as some degree of climate change is becoming inevitable and the ability to limit it is becoming apparent, a new focus on climate change adaptation—"climate smart conservation"—is rapidly gaining interest and acceptance. This new approach to managing natural resources in a shifting environment places emphasis on anticipating and preparing for change by ensuring that existing and new conservation efforts are designed to be effective and relevant in an altered climate.

"Climate Smart Adaptation: A Guide for On-the-ground Action" will be held in conjunction with the 77th North American Wildlife and Natural Resources Conference on Monday morning, March 12, 2012, at the Hilton Atlanta in Atlanta, Georgia. The workshop will address the challenge of developing guidance and reaching consensus on what climate smart conservation means and how to apply the tenets of climate smart adaptation.

Spatial Planning for Biodiversity in Europe’s Changing Climate

Elizabeth Wilson* and Jake Piper
School of the Built Environment, Oxford Brookes University, Oxford, UK

ABSTRACT
Climate change is already having impacts on biodiversity within Europe, with habitats and species needing to change and adapt to rising global temperatures and shifts in bio-climatic zones.

Spatial planning represents an important intervention to further European, national and local biodiversity objectives for climate change adaptation. Drawing on case-studies of plans for inland and coastal areas, and involving stakeholder workshops, this paper reports on a trans-national study examining the scope of spatial plans in the Netherlands, England and France in addressing the impact of climate change. It concludes that spatial planning is making provision for biodiversity and dynamic natural processes. However, while good practice in planning for biodiversity under conditions of climate change is developing, systematic use is not being made of available procedures. The paper examines some of the barriers to implementation.

2009 California Climate Adaptation Strategy Discussion Draft
A Report to the Governor of the State of California in Response to Executive Order 5-2008

Massachusetts Climate Change Adaptation Report
September 2011
Submitted by the Executive Office of Energy and Environmental Affairs and the Adaptation Advisory Committee
Avian Responses to Climate and Land-use Variability and Change
Breeding Bird Survey

4300+ road transects
Volunteers
Started in 1967
View and Explore Data

Range and Point Maps
Explore interactive range maps by species or subspecies — zoom in for details

Bar Charts
Find out what birds to expect throughout the year in a region or location

Line Graphs
Explore different metrics of species occurrence in a region or location

Your Totals
Track your totals and compare with other eBirders.

Yard Totals
How many species and checklists have you submitted for your yard?

Patch Totals
How many have you submitted for your favorite birding patches?

Top 100
Compare with the top eBirders in your region.

Arrivals and Departures
Arrivals and departures for a country, state/province, county, or hotspot

All-Time First/Last Records
All-time records for species arrival and departure in a region
Model Bird Responses to NDVI and NDVI Departures as well as Land Cover Changes (from the NLCD)
Ecosystem Services and Landscape Research

- Assessment of national in-situ biological/ecological monitoring programs to capture landscape gradients
- Pattern analyses at relatively fine scales (30 meters using National Land Cover database) across the US … to identify areas with different landscape patterns and design
- Use in-situ data and pattern gradient to evaluate response (to different landscape patterns and designs)
- Evaluate multiple ecosystem services
National Monitoring Programs

Key Issue: Can existing monitoring programs be retrofitted to evaluate landscape designs for ecosystem services. How well do they capture landscape gradients?
Current landscape pattern metrics fail to capture many types of designed conservation measures.

Huntsville, AL

Black = Forests
White = Ag and Developed
Developing metrics to find areas that have greater or lower connectivity than expected given the amount of the land cover or land use … to evaluate ecosystem services.
National Land Cover Dataset (NLCD)

(30 m resolution)
NAIP 1 m Resolution Aerial Photography (national coverage every two years)
An example of an overperforming area ... an area with 19% forest that functions more like an area with 60% forest (Reston, VA)
Stream and River Ecosystem Monitoring Data ... 1995-2006
Bug Conditions:
1: LEAST DISTURBED
2: INTERMEDIATE DISTURBANCE
3: MOST DISTURBED
9: NO DATA

States with data:
- Water dev - open space
- Low intens dev
- Med intens dev
- High intens dev
- Bare ground
- Decidious forest
- Coniferous forest
- Mixed forest
- Shrub
- Grassland
- Pastureland
- Cropland
- Woody wetland
- Emergent herb wetland

EPA Wadeable Streams Survey (1800 samples) and NLCD 2000 Land Cover

Mid-western US

Dark Brown is Cropland
Green is Forest
Red is Urban

Macro Inverts (O/E)
- 1: LEAST DISTURBED
- 2: INTERMEDIATE DISTURBANCE
- 3: MOST DISTURBED
- 9: NO DATA
Forest Riparian Buffer

Similar site in region was poor, but had a different history
Regression Tree Analysis … Importance of riparian woodland in agricultural catchments

NLC ≤ 68.3
[6.3]
N = 476
(0.45)

ALC ≤ 60.2
[7.2]
N = 177
(0.07)

RIPF ≤ 50.3
[6.9]
N = 111
(0.04)

RIPF ≤ 85.5
[7.7]
N = 66
(0.04)

Node 1
[3.2]
Good - 3
Fair - 21
Poor - 55

Node 2
[8.5]
Good - 19
Fair - 8
Poor - 5

Node 3
[2.2]
Good - 1
Fair - 13
Poor - 35

Node 4
[8.1]
Good - 11
Fair - 3
Poor - 3
Optimizing for Multiple Ecosystem Services

- Regionally Significant Stepping Stone for Migratory Birds
- Most Important Forest Patch to Filter Nutrients and Sediment from Cropland (Carbon Sequestration plus Water Quality)
- Most Important Riparian Forest for Community Water Quality

Different landscape processes associated with different ecosystem services result in different solutions on what to protect and which has more relative value.
The End