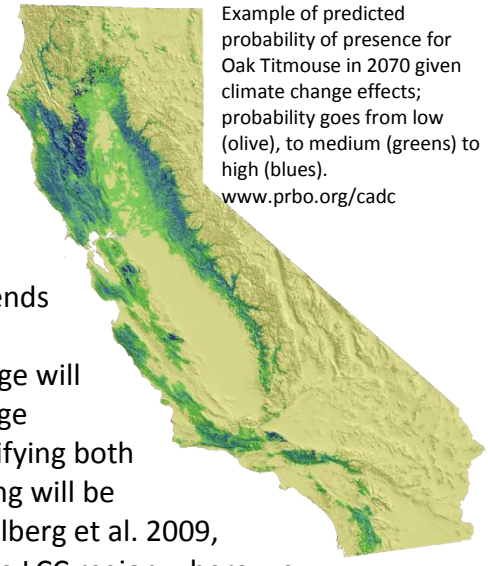
Project Leader/Agency/Contact Information: Grant Ballard, PRBO Conservation Science, 3820 Cypress Drive #11, Petaluma, CA 94954, 707.781.2555 x340, gballard@prbo.org

Title: How do we monitor the ecological consequences of climate change? Developing an Environmental Change Network in the California LCC: Year 1 Landbird Focus



Example of predicted probability of presence for Oak Titmouse in 2070 given climate change effects; probability goes from low (olive), to medium (greens) to high (blues). www.prbo.org/cadc

Project Summary: The uncertainty of predicting future impacts of climate change on biodiversity and ecosystems indicates we cannot rely on models alone, but must also monitor environmental change in real time. Our project will develop a foundation for monitoring environmental change by identifying where and what to monitor in order to evaluate climate-change impacts. Although our initial monitoring focus will be on landbirds, we will develop a framework that recommends standardized monitoring for other taxa (e.g., pollinators) and environmental attributes (e.g., bud-break timing). Climate change will not have the same effects in all locations – some areas will change quickly (hotspots) and others will change slowly (refugia). Identifying both types of areas and monitoring the rate at which they are changing will be important. Building on models we have already developed (Stralberg et al. 2009, Wiens et al. 2009; see figure), we will identify the locations in the LCC region where we predict the greatest changes in climate, habitats, and bird communities. We will use these same models to prioritize the landscape based on the conservation value under current and predicted climates. We will use the places identified by our analyses and the recommendations from a workshop as the foundation for a monitoring protocol to *detect* and *attribute* the effects of environmental change on biodiversity – an Environmental Change Network (Morecroft et al. 2009). We will provide an LCC-specific web portal where users can view predicted distributional changes in landbird, habitat, and climate under future climate conditions, updated with new data as they become available.

Project Goals: The overarching goal of the LCC Environmental Change Network is to guide and prioritize conservation activities that benefit biodiversity while conserving ecosystems.

Specific "year 1 grant lifecycle" objectives include:

1. Create spatial products that show areas of change in bird populations, habitats, and temperature and precipitation due to climate change.
2. Recommend a monitoring protocol & population metrics for landbirds in the LCC region.
3. Create an LCC-specific web portal to archive and share all spatial products (visually and downloadable), data, and other resources as they become available.

Long-term objectives include:

1. Establish and maintain a network of monitoring sites within LCC boundaries to obtain comparable long-term datasets by monitoring key variables of importance to the LCC.
2. Provide integration and analysis of these data, to enable early identification of environmental changes and improve understanding of their causes.
3. Distinguish short-term fluctuations from long-term trends, and project future changes.

4. Develop and disseminate monitoring data and natural-resource management recommendations to public and private interests.

Partners: Our research and conservation partners include CVJV, SFBJV, CA Dept. of Fish & Game, The Nature Conservancy, Coastal Conservancy, U.S. Fish and Wildlife Service, Cornell Lab of Ornithology, Audubon California, USGS, and several University researchers. Because our priority is to make data and results widely available, several other partners could benefit from this project.

How project will advance LCC goals: This project advances LCC goals by contributing to the following: ***Areas of Emphasis*** - Climate Information, Land Cover, Data Sharing, Management and Interfacing, Habitat Connectivity (hot spots), Species and Habitat Information, and Communications and Information Exchange. LCC ***Project Considerations*** - it meets multiple LCC needs, benefits other LCCs, has multiple partners, leverages funding and personnel, shows immediate results, sets the LCC up for long-term success, helps the Fish and Wildlife Service achieve desired accomplishments for end-of-fiscal-year reporting, improves the understanding of how species, habitats, and landscapes adjust to stressors, including climate and land use change, and addresses existing resource goals/plans/priorities of LCC partners. LCC ***Desired Accomplishments for 2010*** - risk and vulnerability assessment developed or refined for priority species and habitats, monitoring protocols developed or refined to capture data on fish and wildlife populations and their habitats to detect changes resulting from climate change, population and habitat assessment developed or refined to predict changes in species populations and habitats, and a biological planning and conservation design project developed in response to climate change.

Methods: Our project will be implemented in two phases. In the first phase, we will develop several spatially-explicit models. In the second phase, we will use the models to develop the monitoring program. Results from the models will also help prioritize conservation and restoration activities and places, and all will be made available via an LCC-specific landbird monitoring web portal.

PHASE 1: Predict Areas of Change and Identify Future Conservation Priorities

Identify/map areas with the greatest climate-change related to changes in bird species distribution and diversity. We will update results of present and future species distributions after assessing output from several newly available modeling alternatives (including boosted regression trees and random forest machine learning techniques) then use community ecology indices (co-occurrence and niche overlap) to quantify the change, displaying degrees of change by each metric. Bootstrapped confidence intervals for the indices will indicate if current values are included in the intervals, providing threshold indicators of change that can be compared across modeling alternatives for support.

***Identify areas with the greatest change in future climate*.** We will use multivariate analyses to collapse the many variables that go into climate-change models into climate gradients that can be used to calculate the projected change in overall climate for each 800 m^2 grid cell of the California LCC. We will then use this information to identify areas likely to experience the greatest changes in overall climate.

***Develop a spatial prioritization of bird conservation priorities in a climate change context*.** We will apply Zonation conservation planning software (Moilanen 2007) to our existing models of present and future species distribution to develop hierarchical conservation priorities of current, future, and combined geographies for landbirds in the California LCC. The Zonation-derived priority areas will differ from diversity hotspots in that core areas for all focal species will be simultaneously retained. Results will be compared with Upland Goals Project's Conservation Lands Network for the San Francisco Bay region, as well as existing protected area networks, and will be used to inform monitoring strategy development.

***Design and implement a web portal to view spatial information, deliver GIS products to partners*.** We will develop and provide a portal where visitors can view and download raw data, grid and ArcGIS shape files, and maps of the abovementioned products. We will provide our partners with on-line access to advanced modeling tools, co-variate data, and automatically-updatable web objects ("widgets") of selected products to be attached for display in the LCC's own landbird monitoring portal and in "live" web reports.

PHASE 2: Use Predictive Models and Expert Workshop to Design a Monitoring Protocol

***Convene workshop with subject experts to determine best monitoring subjects and metrics*.** We will use results from Phase 1, the United Kingdom Environmental Change Network model (Morecroft et al. 2009), and our knowledge of the LCC region to develop a preliminary list of monitoring subjects. We will then invite subject-area experts with monitoring experience to attend a one day workshop and develop recommendations for what and where to monitor in the LCC.

Produce monitoring report that recommends metrics, study locations, and protocols. We will use the results from Phase 1 and from the workshop to produce a report that makes specific recommendations for a landbird-monitoring protocol and general recommendations for additional monitoring subjects, metrics, and locations.

Products: Two major products will serve to organize and deliver the individual project components as described in Methods: (1) ***A California LCC-specific landbird monitoring web portal***. The portal will allow users to access, view, and download all results developed for the LCC. (2) ***A monitoring recommendations report***. The report will inform the LCC with respect to "what" and "where" to monitor, with an emphasis on landbirds.

Is the Project on-going? The project is not on-going *per se* but it does build extensively on our previous climate modeling work and is a needed and useful "next step" application of those models. **If so, describe: 1. what has been completed to date:** See Stralberg et al. 2009, Wiens et al. 2009, and http://data.prbo.org/cadc2/index.php?page=climate-change-distribution to see what has been completed to date with respect to climate change modeling. For web portal and online tools, see the California Avian Data Center www.prbo.org/cadc. **2. who has supported it, both fiscally and in-kind:** Our work on climate change modeling was primarily supported by an anonymous donor. Our work developing the California Avian Data Center was primarily supported by the National Science Foundation. **3. what will this proposal add to the project:** This project capitalizes on and is a powerful extension of existing work (see www.prbo.org/cadc and http://www.prbo.org/cms/553).

Timetable for Completion (identified by each deliverable):

Project Deliverable	Aug 2010	Sept 2010	Oct 2010	Nov 2010	Mar 2011
Identify areas with greatest change in bird species distribution and diversity	X				
Identify areas with greatest change in several components of temperature and precipitation		X			
Develop spatial prioritization of bird conservation targets in a climate change context		X			
Design & implement web portal to view spatial data, deliver GIS products, etc.			X		
Convene workshop with subject experts to determine best monitoring subjects/metrics				X	
Produce monitoring report that recommends metrics, study locations, and protocols					X

Performance Metrics with Timeline for each: Our success will be measured by the number and frequency of individuals that use the LCC-specific web portal including the number of downloads (raw data, grid and ArcGIS shape files, and maps). By extension, our performance can be measured by the number of times our products are used for conservation planning purposes and in the scientific studies of other researchers. There is not fixed timeline for this; it's ongoing. We will also be successful if we can attract productive scientists to participate in the workshop and review our monitoring recommendations report. See timeline above for this.

Conservation Outcomes: Our project will help the LCC achieve on-the-ground conservation outcomes in several ways. Given the uncertainty associated with climate change and the logistical and financial constraints to implementing restoration and conservation actions, conservation efficacy will be enhanced by planning that uses ecologically-based methods for prioritizing actions. Thus, results from our climate change modeling will not only identify the places most suited to evaluate the effects of climate change, but also those areas that will be the most important to conserve via acquisition, restoration, and/or connectivity. Because conservation effectiveness is also enhanced by the timely sharing and dissemination of information, our LCC-specific web portal will serve to share relevant results, data, etc. within a nearly real-time framework. Finally, the uncertainty associated with future climate and land-use changes requires monitoring to continuously evaluate our assumptions and conservation actions, and adapt as needed. Our Environmental Change Network concept is suited to the task of detecting change *and* assessing causes for the change.

Literature Cited:

Moilanen, A. 2007. Landscape Zonation, benefit functions and target-based planning: Unifying reserve selection strategies. Biol. Cons. 134:571-579.

Morecroft, M.D., C.E. Bealey, D.A. Beaumont, S. Benham, D.R. Brooks, T.P. Burt, C.N.R. Critchley, J. Dick, N.A. Littlewood, D.T. Monteith, W.A. Scott, R.I. Smith, C. Walmsley, and H. Watson. 2009. The UK Environmental Change Network: Emerging trends in the composition of plant and animal communities and the physical environment. Biol. Cons. 142:2814–2832.

Stralberg, D., D. Jongsomjit, C. A. Howell, M. A. Snyder, J. D. Alexander, J. A. Wiens, and T. L. Root. 2009. Reshuffling of species with climate disruption: a no-analog future for California birds? PLoS ONE 4:e6825. doi:10.1371/journal.pone.0006825

Wiens, J.A., D. Stralberg, D. Jongsomjit, C.A. Howell, and M.A. Snyder. 2009. Niches, models, and climate change: Assessing the assumptions and uncertainties. Proc. Natl. Acad. Sci. USA 106:19729-19736.

Budget: The following budget is organized by product:

PRODUCT #1: CA LCC Landbird Monitoring Web Portal

EXPENSES	Amount
Salaries and Benefits	
Grant Ballard (project coordination, CADC lead) [$9,949/mo. x 1.25 mos.]	$12,436
Michael Fitzgibbon (lead engineer) [$7,745/mo. x 2 mos.]	$15,490
Thomas Gardali (input on portal design) [$8,466/mo. x 0.25 mos.]	$2,117
Stralberg / Salas (create revised models) [$7,730/mo. x 2 mos.]	$15,460
Sub-total	$45,503
Total Direct Costs	$45,503
Indirect Costs (33.5%)	$15,243
Total Outcome Expenses	$60,746
FUNDING	
Requested from CA LCC (pending)	$47,046
NOAA SARP (awarded)	$13,700
Total Outcome Funding	$60,746

PRODUCT #2: Monitoring Recommendations Report

EXPENSES	Amount
Salaries and Benefits	
John Wiens (workshop leader, report author) [$14,698/mo. 1.0 mos.]	$14,698
Thomas Gardali (report author) [$8,466/mo. 1.0 mos.]	$8,466
Grant Ballard / Geoff Geupel (report author) [$9,949/mo. 0.5 mos.]	$4,975
Nathaniel Seavy (report author) [$6,945/mo. 2.5 mos.]	$17,363
Sub-total	$45,501
Supplies (food for workshop)	$500
Travel (travel, accommodations for subject area experts)	$4,500
Total Direct Costs	$50,501
Indirect Costs (33.5%)	$16,918
Total Outcome Expenses	$67,419
FUNDING	
Requested from CA LCC (pending)	$39,019
S.D. Bechtel Foundation (in hand)	$8,400
Anonymous Donor (in hand)	$10,000
CALFED (in hand)	$10,000
Total Outcome Funding	$67,419

Total Request from the LCC: $86,065 (see Budget above for details).

Matching Funds: $42,100 (see Budget above for details).

Letters of Support:

1) Greg Golet, The Nature Conservancy
2) Hugh Safford, USDA Forest Service
3) Stuart Weiss, Creekside Center for Earth Observation

May 27, 2010

Debra L. Schlafmann
California Landscape Conservation Cooperative
Pacific Southwest Region (Region 8)
U.S. Fish and Wildlife Service
2800 Cottage Way, Suite W-2606
Sacramento, CA 95825

RE: PRBO Conservation Science Funding Requests for developing a monitoring network for detecting changes resulting from climate change in the California Landscape Conservation Cooperative

I am writing to recommend that the California Landscape Conservation Cooperative approve the requests for funding from PRBO Conservation Science for the project entitled "*How do we monitor the ecological consequences of climate change? Developing an Environmental Change Network in the California Landscape Conservation Cooperative: Year 1 landbird focus*". This project will identify the places most suited to evaluate changes due to climate change and also those areas that are going to be the most important to conserve via acquisition, restoration, and/or connectivity. It will lay the groundwork for monitoring environmental change by identifying where and how we should monitor in order to evaluate climate change impacts on ecological systems.

PRBO has several core strengths that make it uniquely suited to lead this project and develop important science and conservation tools that will help the LCC in achieving its goals. Some of the core strengths that will help PRBO succeed in their proposed work are: experience in conservation science, an ethic of partnership building, well-developed informatic infrastructure, and expertise in climate change effects on wildlife.

Conservation science experience. Since 1965, PRBO has been collecting data and using science to improve conservation. Their work has addressed topics ranging from restoration of riparian wildlife habitat in the Central Valley to fire ecology in the Sierra Nevada. The experience that PRBO brings to this project will help make this an important contribution to the California LCC.

Partnerships. PRBO has forged diverse partnerships to address some of our most important conservation challenges. In some cases, PRBO has led these partnerships to generate important products, like the California Partners in Flight Habitat Conservation Plans. In other cases, such as the Joint Ventures in California, PRBO has served as a supporting partner that helps make the efforts of these groups more efficient and more effective. This project brings PRBO's expertise in effective partnerships for conservation to the table to address the immense challenges that climate change poses for wildlife conservation in California.

Informatics. Recently, PRBO has invested in building the informatics capacity of the organization. Already, this capacity has grown beyond the organization, in the form of the California Avian Data Center (CADC). CADC now supports the information needs for many outside organization, such as the bird data for the US Forest Service Management Indicator Species Program in the Sierra Nevada. The project proposed by PRBO will leverage their informatics tools to provide the LCC a framework for storing, accessing, and visualizing data to enhance our understanding of how climate change is influencing wildlife habitat in California.

Climate change effects on wildlife. PRBO is actively engaged in developing science to understand and address the ecological consequences of a rapidly changing climate. Over the last several years, PRBO scientists have been the lead authors on climate change papers published in journals including *PNAS*, *PLoS One*, *Ecological Restoration*, and *Global Change Biology*. Additionally, PRBO scientists have been engaged in numerous workshops and conferences addressing ecological adaptation to climate change. This project will draw on this experience.

The work PRBO proposes to do will be helpful to our efforts as we work to craft a regional strategy for adapting to the impacts of climate change in California, assessing the vulnerability of birds and other wildlife to climate change, and monitoring how rapidly climate change is impacting California's unique flora and fauna. Therefore, I fully support PRBO's proposal to begin the work on identifying the places most suited to evaluate changes due to climate change and also those areas that are going to be the most important to conserve via acquisition, restoration, and / or connectivity. I urge the California Landscape Conservation Cooperative to fund it in full.

Sincerely,

Greg Golet, Ph.D.
[signed electronically]

The Nature Conservancy

United States Department of Agriculture

Forest Service

Pacific Southwest Region

Regional Office, R5
1323 Club Drive
Vallejo, CA 94592
(707) 562-9130 Text (TDD)
(707) 562-8934 Voice

Date: May 25, 2010

Subject: PRBO Conservation Science Funding Request for developing a monitoring network for detecting changes resulting from climate change in the California Landscape Conservation Cooperative

To: Debra L. Schlafmann, California Landscape Conservation Cooperative, Pacific Southwest Region (Region 8), U.S. Fish and Wildlife Service, 2800 Cottage Way, Suite W-2606, Sacramento, CA 95825

Dear Debra,

I am writing to recommend that the California Landscape Conservation Cooperative approve the request for funding from PRBO Conservation Science for the project entitled "*How do we monitor the ecological consequences of climate change? Developing an Environmental Change Network in the California Landscape Conservation Cooperative: Year 1 landbird focus*". This project will identify the places most suited to evaluate changes due to climate change and also those areas that are going to be the most important to conserve via acquisition, restoration, and / or connectivity. It will lay the groundwork for monitoring environmental change by identifying where and how we should monitor in order to evaluate climate change impacts on ecological systems.

PRBO has long experience in conservation science, an ethic of partnership building, a well-developed informatics infrastructure, and expertise in recognizing and mitigating the impacts of climate change on wildlife. These strengths make PRBO very well-suited to lead this project and develop important science and conservation tools that will help the LCC in achieving its goals.

Conservation science experience. Since 1965, PRBO has been collecting data and using science to improve conservation. Their work has addressed topics ranging from restoration of riparian wildlife habitat in the Central Valley to fire ecology in the Sierra Nevada. The experience that PRBO brings to this project will help make this an important contribution to the California LCC.

Partnerships. PRBO has forged diverse partnerships to address some of our most important conservation challenges. In some cases, PRBO has led these partnerships to generate important products, like the California Partners in Flight Habitat Conservation Plans. In other cases, such as the Joint Ventures in California, PRBO has served as a supporting partner that helps make the efforts of these groups more efficient and more effective. This project brings PRBO's expertise in effective partnerships for conservation to the table to address the immense challenges that climate change poses for wildlife conservation in California.

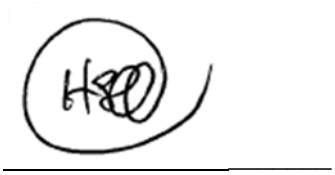
Informatics. Recently, PRBO has invested in building the informatics capacity of the organization. For example, the California Avian Data Center (CADC), which was the brainchild of PRBO, now supports the information needs for the bird data for our (US Forest Service) Management Indicator Species Program in the Sierra Nevada. The project proposed by PRBO will leverage their informatics tools to provide the LCC a framework for storing, accessing, and visualizing data to enhance our understanding of how climate change is influencing wildlife habitat in California.

Climate change effects on wildlife. PRBO is actively engaged in developing science to understand and

address the ecological consequences of a rapidly changing climate. Over the last several years, PRBO scientists have been the lead authors on climate change papers published in major journals including *PNAS*, *PLoS One*, *Ecological Restoration*, and *Global Change Biology*. Additionally, PRBO scientists have been engaged in numerous workshops and conferences addressing ecological adaptation to climate change. This project will draw on this experience.

The work PRBO proposes to do will be helpful to our efforts as we work to craft a regional strategy for adapting to the impacts of climate change in California, assessing the vulnerability of birds and other wildlife to climate change, and monitoring how rapidly climate change is impacting California's unique flora and fauna. Therefore, I fully support PRBO's proposal and I urge the California Landscape Conservation Cooperative to fund it in full.

Sincerely,



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May 27, 2010

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2800 Cottage Way, Suite W-2606
Sacramento, CA 95825

RE: PRBO Conservation Science Funding Request for developing a monitoring network for detecting changes resulting from climate change in the California Landscape Conservation Cooperative

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I have worked with PRBO scientists over the past decade on a number of projects, including the USFWS Tidal Marsh Species Recovery Plan, and the San Francisco Bay Area Upland Habitat Goals Project. I have always been impressed with their science capabilities and accomplishments, and their focus on providing important science and conservation tools for practitioners. They are one of the great scientific and conservation resources in California.

PRBO has strengths that make it uniquely suited to lead this project that will help the LCC in achieving its goals. Their core strengths include: experience in conservation science, an ethic of partnership building, well-developed informatics infrastructure, and expertise in climate change effects on wildlife.

Conservation science experience. Since 1965, PRBO has been collecting data and using science to improve conservation in the LCC area and elsewhere in California. Their work has addressed topics ranging from restoration of riparian wildlife habitat in the Central Valley to fire ecology in the Sierra Nevada. Their consistently high scientific standards, from fieldwork to modeling, are key assets.

Partnerships. PRBO has forged diverse partnerships. In some cases, PRBO has led these partnerships, like the California Partners in Flight Habitat Conservation Plans. In other cases, such as the Joint Ventures in California, PRBO has served as a supporting and effective scientific partner. My experiences with PRBO as a partner has been productive, and their focus on the science shines through. This project would benefit from PRBO's expertise in effective partnerships for conservation to address the immense challenges that climate change poses for wildlife conservation in California.

Informatics. Recently, PRBO has invested in building the informatics capacity of the organization. Already, this capacity has grown beyond the organization, in the form of the California Avian Data Center (CADC). CADC now supports the information needs for many outside organization, such as the bird data for the US Forest Service Management Indicator Species Program in the Sierra Nevada. PRBO

will leverage their informatics tools to provide the LCC a framework for storing, accessing, and visualizing data, and incorporating it into other conservation planning processes such as Upland Habitat Goals.

Climate change effects on wildlife. PRBO is actively engaged in developing science to understand and address the ecological consequences of a rapidly changing climate. Over the last several years, PRBO scientists have been the lead authors on climate change papers published in journals including *PNAS*, *PLoS One*, *Ecological Restoration*, and *Global Change Biology*. Additionally, PRBO scientists have been engaged in numerous workshops and conferences addressing ecological adaptation to climate change. I have attended many of these and PRBO always brings great science and insights to the table.

The PRBO proposal will advance our efforts as we craft regional strategies for adapting to climate change in California, assessing the vulnerability of birds and other wildlife to climate change, and monitoring how rapidly climate change is impacting California's unique flora and fauna. Therefore, I fully support PRBO's proposal to USFWS and I urge the California Landscape Conservation Cooperative to fund it in full.

Sincerely,

[signed electronically]

Stuart B. Weiss

Chief Scientist

Creekside Center for Earth Observation