

Project Title:

Decision support for climate change adaptation and fire management strategies for at risk species in southern California

Proposal by:

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Scope & Budget:

Location: Southern California
Duration in months: 12
Requested Funding: \$99867.20
Leveraged Funding: \$50840

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Briefly summarize the goals of the project, what products will result, and how the products support decision-making and conservation delivery for natural resource management within the CA LCC.

We propose to develop a framework to support decision making for management of threatened species and habitats in southern California's fire-prone ecosystems. This framework will support identification of adaptation strategies such that the most prominent threat is identified, and integrated management strategies can be devised to address multiple interacting threats. Our objectives are: 1) to integrate a) fire risk models, b) SDMs and c) population models with scenarios of future climate and land cover to project how the effects of climate-induced changes to species distributions and land use change will impact threatened species in fire-prone ecosystems; and 2) to identify and prioritize potential management responses to climate change (e.g. assisted colonization, fire management, land protection, dispersal corridors). Importantly, the proposed research addresses multiple, potentially interacting, threats. This will assist land and natural resource managers in developing climate change adaptation strategies for structured decision making in the face of risk and uncertainty. Anticipated products include: maps (digital and hard copy) of habitat suitability under current and future climate change, current and future projected urban growth and combinations of climate change and future projected urban growth, under the two most appropriate climate scenarios for southern California; linked population models and dynamic bioclimate envelopes that will form the basis for testing climate change adaptation options and other management scenarios; spatially/temporally explicit recommendations on the most suitable management option (in terms of population improvement under climate change and urban growth) for each species addressed; spatially explicit recommendations for functional types, and habitat specialist types, on the most suitable management option; an adaptive management framework for structured decision making that can be updated as new information becomes available.

For continuing 2010 CA LCC projects, describe the accomplishments and outcomes to date, why additional funds are needed, and what this proposal will add to the project.

NEW PROJECT

Identify which National LCC Performance Measure(s), if any, your project addresses.

1. A risk and vulnerability assessment developed or refined for priority species and habitats. 3. A population and habitat assessment developed or refined to predict changes in species populations and habitats. 4. A biological planning and conservation design project developed in response to climate change. 5. A management evaluation action evaluated for effectiveness in response to climate change and research activities conducted to address information needs in response to climate change.

List Partners

Dr Helen M. Regan, Associate Professor, Biology Dept, University of California Riverside, CA Dr Kurt E. Anderson, Assistant Professor, Biology Dept, University of California Riverside, CA Dr Janet Franklin, Professor, School of Geographical Sciences, Arizona State University, Tempe, AZ Dr Alexandra D. Syphard, Senior Ecologist, Conservation Biology Institute, San Diego, CA Clark S. Winchell, Division Chief (starting 08 May 2011), Conservation Partnerships Program, U.S. Fish & Wildlife Service, Carlsbad, CA Keith Greer, Senior Environmental Planner, Land Use and Transportation Planning, San Diego Association of Governments

Briefly describe how the project team (main PIs) provides the range of experience, expertise, and organizational capacity needed to accomplish the project. List recent and current projects (names, time-periods, PI time commitments, and total budgets). Also attach 1 page CVs for the principle investigator and/or project leaders per below under additional information.

The research team that we have assembled has an ideal set of complementary skills for addressing the priority needs of management of biodiversity under climate change in the call for proposals. Collectively, we have considerable expertise in fire-prone ecosystems, fire ecology and modeling, population modeling, landscape ecology and modeling, species distribution modeling under climate change, ecological decision making under risk and uncertainty and practical management expertise relevant to key agencies in our region of focus. Regan (University of California Riverside) has expertise in conservation biology, spatially explicit population modeling of plant species (including linking dynamic bioclimate envelopes and population models), risk assessment and decision making under uncertainty. Anderson (University of California Riverside) has expertise in mark-recapture analysis, analysis of environmental variability, dispersal and population modeling of animal species. Franklin (Arizona State University) has expertise in landscape ecology, plant ecology, community and vegetation dynamics, and species distribution modeling. Syphard (Conservation Biology Institute) has expertise in landscape ecology, urban growth modeling, fire modeling and incorporating climate change data into species distribution models. Winchell (Carlsbad Fish and Wildlife Office) has expertise in biomonitoring, data analysis and practical land and resource management currently focusing on California Natural Community Conservation Planning (NCCP) and the San Deigo Multiple Species Conservation Program (MSCP). Greer (San Diego Association of Governments) has expertise in practical land-use planning, natural resource management, monitoring and land acquisition for habitat conservation plans, with particular focus on the Multiple Species Conservation Program (MSCP). All members of the project team have predominantly worked on practical conservation, management and ecological issues in California and have collaborated with a wide network of scientists, managers and policy makers in southern California. All members of this team have worked together, in some combination, on previous projects (see Main Proposal Structure document for details). Projects Regan: 2011-2015 (accepted, in process of being awarded). NSF Macroecology. Collaborative Research: Do micro-environments govern macroecology? (co-PI) \$3,362,527. Time commitment (1 month summer per year; 5% AY) 2010-2012 (current). Californian Cooperative Ecosystems Studies Unit & Department of Defense. Development of Fire Management Tools at Marine Corps Base Camp Pendleton. (PI) \$99,634 (1 month summer per year; 5% AY). 2010-2011 (completed). DOE National Institute for Climate Change Research. Climate change impacts on plant functional groups in a biodiversity hotspot. (PI) \$125,000. (1 month summer; 5% AY) 2008-2011 (current). NSF Directorate of Biological Sciences. Collaborative Research: The persistence of biodiversity in southern California under future land-change scenarios. (PI) \$450,000 (0.5 - 1 month summer per year; 5%

AY). 1/1/05-12/31/06 (completed). Local Assistance Grant: Assess and improving the San Diego Multiple Species Conservation Program (MSCP) Biological Monitoring Plan, California Dept Fish & Game. (co-PI) \$200K. (5% AY, 1 month summer salary per year) Anderson: Pending. National Science Foundation. Modeling spatial population dynamics in branching river networks using quantum graphs (PI). \$459,318. (2 month summer; 25% AY) 2009-2010 (completed). Public Interest Energy Research Program, California Energy Commission. Integrating bioenergetics, spatial scales, and population dynamics for environmental flow assessments (Co-PI). \$138,400. (17% AY) 2009-2010 (completed). Naval Facilities Engineering Command. Technical assistance on the habitat fragmentation study in the vicinity of Naval Base Pt. Loma and MCAS Miramar. (PI). \$12,768. (30% AY) 2008-2009 (completed). Naval Facilities Engineering Command. Technical assistance on the habitat fragmentation study in the vicinity of Naval Base Pt. Loma and MCAS Miramar. (PI). \$7,842. (28% AY) 2005-2008 (completed). U.S. Dept. of Agriculture National Research Initiative Postdoctoral Fellowship, CSREES Award # 2005-35302-16997. Spatial population dynamics of pest herbivores on plants with inducible resistance: A theoretical framework. (PI) \$125,000. (100% AY) Franklin: 1/1/05-12/31/06 (completed). Local Assistance Grant: Assess and improving the San Diego Multiple Species Conservation Program (MSCP) Biological Monitoring Plan, California Dept Fish & Game. (PI) \$200K. (5% AY, 0.50 month summer salary per year) 04/01/10 - 03/31/11 (completed). Dept of Energy, NICCR. Climate change impacts on plant functional groups in a biodiversity hotspot. (co-PI) \$125K (5% AY, 0.50 month summer salary per year) 2008-2011 (current). NSF Directorate of Biological Sciences. Collaborative Research: The persistence of biodiversity in southern California under future land-change scenarios. (co-PI) \$450,000 (0.5 - 1 month summer per year; 5% AY) 04/15/11 - 04/16/16 (accepted, in process of being awarded). NSF Macroecology. Collaborative Research: Do microclimates govern macroecology? (\$275,578 Franklin's portion) (5% AY, 1 month summer salary per year) Syphard: 07/01/08 – 06/30/11 (current). NSF-Directorate for Biological Sciences (BIO). Collaborative Research: The Persistence of Biodiversity in Southern California Under Future Land-Use Scenarios. (\$95,000 – Syphard's portion) 0.5 FTE, 2008 – 2010, 0.1 FTE 2011 06/01/10 – 09/30/12 (current). U. S. Geological Survey Western Ecological Research Center . Multi-hazards demonstration project: Urban growth and fire risk modeling. (\$95,000 – Syphard's portion) 0.4 FTE 07/01/10 – 06/30/12 (current). Space and Naval Warfare Systems Command (SPAWAR) Understanding and Improving Wildfire Management for Marine Corps Base Camp Pendleton (\$125,000 – Syphard's portion) 0.3 FTE 04/15/11 – 03/30/15 (current). NSF Macrosystems Biology. Collaborative Research: Do microenvironments govern macroecology? (\$157,948 – Syphard's portion) 0.04 – 0.21 FTE 10/01/11 – 09/30/12 (pending). U. S. Geological Survey Western Ecological Research Center. Quantitative Assessment of the Effect of Fuel Manipulation Projects on Fire Behavior and Urban Loss. (\$40,000 – Syphard's portion) 0.2 FTE 03/01/12 – 1/31/15 (pending). Strategic Environmental Research and Development Program (SERDP). A Fire Risk Assessment System for DoD Land Management Under Present and Future Climates. (\$149,909 – Syphard's portion) 0.15 FTE AY = Academic year FTE = full time equivalent

Project Description: We propose to provide a framework to assist in 1) understanding the impacts of climate change on species distributions in fire-prone ecosystems, 2) understanding how changes in fire regimes and species distributions will impact vulnerable taxa in fire-prone ecosystems, and 3) developing climate change adaptation strategies for structured decision making in the face of risk and uncertainty.

Climate is a key factor driving species distributions and ecosystem patterns and processes (IPCC 4th Assessment report). In spite of the variability of future climate projections, there is general agreement that anthropogenic warming will continue in the future with increased climatic variability. Yet it is unknown whether climate change will exacerbate or surpass existing threats, such as habitat loss or altered fire regimes, to native ecosystems. Determining how climate change interacts with other threats and which species are at greatest risk is essential to developing adaptation strategies.

Altered fire regimes, and particularly shortened fire recurrence times, threaten native plants and habitat for native animals. In fire-adapted systems, habitat suitability and population persistence for many species are inextricably tuned to the fire regime, but in recent decades, fire regimes have been altered beyond their natural range of variability. Land use change modifies the spatial and temporal distribution of fire through fire suppression and increased ignitions. Climate change may further exacerbate these effects by altering the drivers of fire, such as fuel moisture, composition, and continuity. Although some species are disproportionately vulnerable to certain threats, such as climate change, it is unclear what the relative vulnerability of different species is to combinations of threats.

Thus far, the primary tool for projecting the impacts of future climate change on species has been species distribution models (SDMs). While SDMs are important tools for projecting how climatic factors are likely to influence species distributions, they do not explicitly incorporate effects due to altered disturbance regimes, movement limitations, population size and viability, or synergies among these factors. Furthermore, the spatial scale of SDMs is often incongruent with available management or adaptation strategies. To overcome these limitations, new approaches have been developed and applied by a group of researchers (including members of this proposal) to integrate SDMs and population models over a variety of climate scenarios and fire frequencies. However, this work has not yet addressed potential management options to address the effects of these threats.

Management of threatened species and their habitat in fire-prone ecosystems critically requires a decision support framework that links information from down-scaled climate data, fire frequency models, SDMs, land use change projections, and population-level responses. Such methodology must address the dynamic nature of highly variable and uncertain systems and the needs of managers in preparing for the effects of climate change on biodiversity. Hence, a framework for guiding management needs to account for species dynamics, risk (due to variability) and uncertainty (due to lack of knowledge).

We propose to develop a framework to support decision making for management of threatened species and habitats in southern California's fire-prone ecosystems. This framework will support identification of adaptation strategies such that the most prominent threat is identified, and integrated management strategies can be devised to address multiple interacting threats. Our objectives are: 1) to integrate a) fire risk models, b) SDMs and c) population models with scenarios of future climate and land cover to project how the effects of climate-induced changes to species distributions and land use change will impact threatened species in fire-prone ecosystems; and 2) to identify potential management responses to climate change (e.g. assisted colonization, fire management, land protection, dispersal corridors). Importantly, the proposed research addresses multiple, potentially interacting, threats.

The following deliverables of the project will be accomplished:

- Maps (digital and hard copy) of habitat suitability under current and future climate change, current and future projected urban growth and combinations of climate change and future projected urban growth, under the two most appropriate climate scenarios for southern California.
- Linked population models and dynamic bioclimate envelopes that will form the basis for testing climate change adaptation options and other management scenarios.
- Spatially/temporally explicit recommendations on the most suitable management option (in terms of population improvement under climate change and urban growth) for each species addressed.

- Spatially explicit recommendations for functional types, and habitat specialist types, on the most suitable management option.
- An adaptive management framework for structured decision making that can be updated as new information becomes available.

CA LCC Priorities addressed (*2011 CA LCC priorities appear in italics*).

Although SDMs can provide important information on species distributions under climate change, there are many management strategies for which SDMs alone are insufficient because they do not directly address species demographics, and hence population-level responses to climate change. It is only through their integration with population models that a range of management scenarios can be evaluated and compared. Our framework will allow us to test a range of scenarios and management alternatives to contrast the consequences of each. We will incorporate adaptation by evaluating the relative benefits (in terms of population persistence) of alternative management actions for reducing impacts on each study species from multiple threats. In this way we gain a *better understanding of demographic responses to climate change, including dispersal and survival*. By considering the two most appropriate and relevant climate models for southern California and across the entirety of endemic species' ranges, a framework for *future scenario planning at landscape and ecoregional scales* can be established. Our approach will identify where distributions of important plant functional types that define ecological communities will shift under climate change and will allow us to evaluate the benefits of alternative corridor scenarios under realistic dispersal parameters thus *identifying future biodiversity hotspots and connectivity needs*.

Urban growth is the major source of land use change in southern California. As part of a current NSF-funded project (with which we are leveraging this proposed work) we have used an urban growth model (SLEUTH; Keith Clark UC Santa Barbara) to predict the pace and location of likely urban growth in southern California in the next 50 years. Although we applied it to examine the effect of future urban growth on distributions of key native plant species in southern California, we have not yet coupled this with a range of conservation management alternatives with respect to climate change and altered fire regimes. However, climate change adaptation and fire management strategies need to be considered in the context of permanent land use change in order to *avoid conflicts between human infrastructure changes and biodiversity/conservation*. By overlaying dynamic urban growth predictions and bioclimate envelopes, and then linking the resulting time series of species distributions with population models, our framework will allow managers to explore population-level conservation management in a fuller threat context than afforded by species distribution models and climate change scenarios alone.

CA LCC Criteria addressed:

1. Applicability to Conservation and Adaptation Decisions - Population models have a relatively long and successful history in informing population-level conservation management decisions. Likewise, SDMs have proved to be essential in conservation planning at landscape and ecoregional scales. By combining these approaches, the benefits of a broad range of management options can be quantitatively compared and contrasted for a range of species. For some species (e.g. obligate seeding plants), fire management may be more urgent than climate change adaptation; for others (e.g. resprouting plants), climate change may necessitate immediate action; and for others (e.g. some animals and annual plants), a combination of both fire management and climate change adaptation may be necessary. Our work will help managers identify the most serious threats to species and prioritize conservation management strategies and provide the foundations for long-term adaptive management as new information becomes available.

2. Ecological or Ecosystem Response to System/Climate Change - Due to the uncertainty in climate projections and the models that use such data, we will compare a range of models to test the robustness of adaptation strategies under different climate scenarios, different SDMs and a range of management alternatives. This will improve understanding about the suite of adaptation strategies that are robust (and conversely, sensitive) to uncertainties in input data.

3. Breadth of Understanding - We will address multiple taxa (both plant and animal species, spanning a range of functional types and ecological communities) and integrate physical data (high

resolution down-scaled climate data, environmental variables correlated with species occurrence, fire frequency, land use change) with biological data (species demographics, fire response, dispersal), enabling a comprehensive understanding of how population decline and/or extinction is affected by land use change, species distribution shifts due to climate change, effects of altered fire regime. It will also enable a better understanding of how populations might respond to different management alternatives.

4. Accessibility – Co-Investigator Syphard works for Conservation Biology Institute, a non-profit research institute that hosts Data Basin, “a free, online system that connects users with spatial datasets, tools, and expertise. Individuals and organizations can explore and download a vast library of datasets, upload their own data, create and publish analysis, utilize working groups, and produce customized maps that can be easily shared.” (<http://databasin.org/about>) Through the Climate Center component of Data Basin we will provide an accessible and highly visible repository for the project deliverables, e.g., the data products listed above. All tangible derived, value-added, non-proprietary data from this project will be made publically available through this portal.

5. Scope/Transferability - Our region of focus is southern California because we have available data for the region and it is where the highest number of threatened species occur. It is salient because of the range of threats and urgency of management actions. However, our framework will be general and thus could be applied to other regions across the LCC. We will use our selected case studies to illustrate a general approach to structured decision making.

6. Partnerships/Leveraging - Members of our team have an established track record of collaboration, thus promoting successful execution of this project. Regan, Franklin and Syphard currently collaborate on NSF-, DOE- and Dept of Defense-funded projects on the effects of climate change, altered fire regime and habitat fragmentation on plant functional groups in southern California, including Marine Corps Base Camp Pendleton. Franklin and Syphard recently collaborated on an NSF-funded project evaluating SDM techniques. Regan and Anderson currently collaborate on the reliability of population models with respect to data availability and quality and on the effects of climate change on the big-eared woodrat (*Neotoma macrotis*). In a recently completed project funded by CDFG, Winchell, Greer, Franklin and Regan, established a strong collaboration that linked land managers, regulatory and monitoring agencies, policy makers and academic scientists in southern California, including CDFG, USGS, BLM, USFWS, California Native Plant Society, City of San Diego, SANDAG and others, to establish a framework for monitoring multi-species habitat conservation plans in the context of myriad threats within the San Diego MSCP. Through our collaborative efforts we produced five technical reports to the CDFG and three peer-reviewed publications, all co-authored by agency personnel and academic scientists. The results of this collaboration are being implemented across southern California.

Our recent and ongoing projects address the effects of climate change, altered fire regime and habitat fragmentation on plants and animals in southern California, but they do not make the next step of exploring structured decision making for management. These projects supported the development of land use change projections, acquisition of high-resolution downscaled climate projections, species distribution modeling protocols and population model structures and parameters sets that will be used in the proposed project. This will leverage expertise and products from basic and applied research in support of CA LCC priorities: conservation and adaptation decisions. These projects also allow the (co-)investigators (Regan, Franklin, Anderson) to devote time to this project as part of our faculty research responsibilities as “in-kind” costs. Managers and policy makers have already asked us to provide recommendations based on our research (e.g., Workshop on Bridging the Gap: Downscaling Climate Models to Inform Management Actions, CDFG, USGS, and USFWS, 3 Nov 2010, Sacramento CA; Tecate Cypress Symposium, TNC and BLM, 16 Jun 2010, Jamul CA). The agency partners are devoting “in-kind” time to providing the management context and implementation framework. If funded, we will apply for a University of California Research Opportunity Grant to hold a workshop for relevant agencies and other eligible CA LCC grantees to provide greater synthesis of climate change adaptation strategies across California.

7. Timeliness and Urgency - Mediterranean-type ecosystems, of which southern California is a part, are particularly vulnerable to climate change due to unique combinations of temperature and precipitation upon which species depend. Due to climate change, urban growth, and changing fire

regimes, southern California is one of the most highly threatened biodiversity hotspots worldwide. Our studies to date reveal that many rare and common species will lose vast proportions of suitable habitat in the near future due to climate change and urban growth. For instance, suitable habitat for Tecate cypress is predicted to all but disappear in the next 50 years under some climate change scenarios; yet, altered fire regime remains the more serious threat. This necessitates immediate action to provide infrastructure and an implementable framework for structured decision making. Our framework will help agencies prioritize the timing, location and scale of management and will assist in identifying the most urgent threats to biodiversity, and the most effective management actions in the face of multiple threats.

Approach and Scope of Work: We will use fine-scale (90 m; USGS) downscaled climate data from two global circulation models (GCMs; GFDL and PCM) under the IPCC A2 emissions scenario to project species distributions and fire patterns under climate change scenarios. This spatial resolution supports, and is consistent with, the spatial scale of most relevant species management options. Our proposed research will link the following set of components:

Species distribution models and habitat suitability maps for species under current and future climate scenarios (predicted out to 100 years), overlaid with projected urban growth (predicted out to 50 years using the urban growth model SLEUTH). We will provide species distributions under current conditions, climate change, urban growth and their combinations using Maxent, Random Forests and GLMs. **Spatially explicit population models** for native and invasive species under current conditions and future climate change scenarios, where data availability allows (predicted out to decades). We will use RAMAS GIS to construct spatially explicit stochastic age/stage-based models that incorporate probabilistic fire events to project population persistence under the range of relevant threats and management scenarios and link these to the dynamic bioclimate/urban growth maps in each time step.

Linking Climate, Land Use Change, and Fire to Population Models:

Step 1. For each study species, changes in potential habitat will be modified based on projections of urban growth, interpolated over the next 50-100 years. These projections have already been developed using the SLEUTH model.

Step 2. Potential habitat for species under current and future climate conditions is generated using species distribution models. For each species, a time series of future changes in the distribution of suitable habitat due to climate change will be interpolated from the SDMs.

Step 3. Maps resulting from Step 2 will overlay maps resulting from Step 1 to produce a series of habitat suitability maps accounting for distribution changes due to climate and land use change.

Step 4. Spatially explicit population viability models will be developed for each species using inputs from the previous steps and linked to fire risk models.

Step 5. In each time step of the population model, the spatial configuration of populations is updated based on the habitat map for that time step. This changes population parameters, including carrying capacities (K), dispersal rates, and demographic rates. Density dependence functions reduce rates of survival and growth independently for particular life stages whenever a population exceeds the carrying capacity (K) of its habitat patch. K is determined from modeled probability of occurrence from the SDM and can be altered by climate change in the SDMs.

We will apply this approach to a range of plant and animal taxa whose life cycles or habitats are impacted by fire and with different dispersal capabilities: e.g. big-eared woodrat (*Neotoma macrotis*), southwestern willow flycatcher (*Empidonax traillii extimus*), and a range of native plant species, *Ceanothus verrucosus*, *Ceanothus greggii*, *Chorizanthe orcuttiana*, *Acanthomintha ilicifolia*, *Quercus engelmannii*, and *Hesperocyparis forbesii*. These species occur in California habitats that are predicted to be affected by climate change, altered fire regime and land use change. We will seek feedback from relevant managers (see partners) on revising this list of species and the feasibility of potential management alternatives. These species will serve as case studies on which to base a *general framework* that can be applied beyond these taxa and this region.

Fire Management: We will investigate the impacts of different fire return intervals on populations across the landscape that represent the desired outcomes from a range of fire management

and reduction strategies. This can be achieved by changing the fire probability models to correspond with proposed fire management objectives. We will investigate the relative benefits of landscape-scale fire management versus strategies targeted to specific locations within the species distribution.

Assisted Colonization: Assisted colonization, or translocation, refers to the timed manual dispersal of species whose current location will lose suitability. The success of assisted colonization programs depends on a number of practical, demographic and habitat related factors such as which individuals are translocated, when this should occur, the survival rates of the translocated individuals, the proximity and habitat stability of recipient patches, the degree to which the source patch contributes to long-term viability of the population, and the nature of the ongoing threats. We will test a range of translocation strategies that vary across the life stages translocated, the proportion of the population translocated, translocation success rates, the frequency of translocation and the number of source and recipient patches under a range of fire frequencies and climate scenarios.

Land conservation: we will test a range of patch protection scenarios to maximize population viability. With the uncertainty inherent in GCMs and SDMs, it will be important for management to identify the sub-populations that currently contribute the most to population viability, in addition to identifying future suitable areas for assisted colonization and migration corridors. By investigating population dynamics in individual patches in the context of land use change and climate change we can determine 1) which sub-populations contribute the most to population viability and 2) which patches are robust to shifts in distributions due to climate change.

Dispersal corridors: we will test dispersal corridor options in a similar way to “assisted colonization.” We will identify undeveloped (presently or in the future) areas that could be set aside for corridors between persistent habitat or habitat that may become suitable under climate change and determine the rate of dispersal through these corridors necessary to promote species persistence. A thorough exploration across potential corridor scenarios will highlight the most robust and feasible option for achieving connectivity under uncertainty in future habitat suitability.

Integrated Management: Due to the uncertainty in climate change predictions, it will be important to develop integrated management plans that “spread” risk across the landscape. In addition to testing management scenarios for each strategy individually, we will also test scenarios that integrate the four types of management described above.

Products/Data Sharing: We will 1) identify the major biodiversity management issues that this region faces under climate change and other threats (Nov 2011), 2) construct maps of habitat suitability for each species under current and future climate change, current and future projected urban growth and combined climate change and future projected urban growth, under the two most appropriate climate scenarios for southern California (Feb 2012), 3) highlight areas robust to climate change, at a fine resolution, that are most suitable for protection or management (March 2012), 4) on a species or functional group basis, identify the most appropriate and timely management actions to maximize population persistence (August 2012), 5) highlight key uncertainties that affect management decisions, be they parameters in the population model, the type of SDM used, or climate model (Sept 2012), 6) upload our derived spatial data sets, maps and population modeling parameter sets into Data Basin (Sept 2012), 7) produce a report that examines the effects of management option for each species (Sept 2012), 8) derive general management principles, where possible, for species in fire-prone ecosystems subject to altered fire regime, land use and climate change (Sept 2012), and 9) produce a manuscript for publication in a peer reviewed journal (Dec 2012). Furthermore, we will establish a link between academic science and practical management. Strong ongoing relationships between the individuals that provide data, concepts and policy needs to be forged for adaptive management to gain traction and continuity. Hence, we believe our most valuable product will be the understanding and common goals forged by working in a network with access to data, methods, management practicalities, and with a vested interest in the region.

Measuring Results: The agency partners will use the products listed above in their development of structured decision making plans.

California Landscape Conservation Cooperative 2011 Proposal Budgets

Budget Categories	CA LCC Request	Partner(s) Contribution(s) (monetary)	Partner(s) Contribution(s) (non-monetary value/in-kind)	Total
Salaries	\$62,707.20	\$ -	\$ 50,340.00	\$ 113,047.20
Supplies	\$1,045	\$ -	\$ 500.00	\$ 1,545.00
Overhead	\$34,165	\$ -	\$ -	\$ 34,165.00
Equipment	\$ -	\$ -	\$ -	\$ -
Other (specify)	\$1,950	\$ -	\$ -	\$ 1,950.00

Total	\$ 99,867.20	\$ -	\$ 50,840.00	\$ 150,707.20
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Other:

Travel for 12 trips to San Diego for meetings with Syphard, the agency partners and to disseminate results is requested (\$1200). Page charges for peer-reviewed publication (\$750).

Budget Justification

Salaries and Wages

Salary for a postdoctoral fellow for 1 year is requested at \$39,756 in accordance with the current University of California academic and staff salary scales. Under guidance and input of the PI and co-PIs the postdoc will link species distribution models to population models and test management scenarios under climate change. S/he will assist Regan and Anderson in population model development for species for which models need to be developed.

Fringe Benefits

Benefits for the postdoctoral fellow are included and estimated at 20%, using the composite rates agreed upon by the University of California.

Supplies and Materials

\$1045 is requested for color map printing (2 maps x 8 species @ \$65.34 per 3 linear ft map; online price list Printing and Reprographics UCR). This is a deliverable of the project to the partner agency and to the sponsor.

Travel

Travel for 12 trips to San Diego for meetings with Syphard, the agency partners and to disseminate results is

requested. 12 trips x 197 miles return trip x \$0.51 allowable mileage for business trip in private vehicle = \$1200. Mileage rate was provided by UCR accounting office.

Consultants

Salary for a subaward to the Conservation Biology Institute is being requested for a total of \$15,000, including benefits and overhead (\$82 per hour). Alexandra Syphard of CBI will work with the postdoctoral fellow to construct species distribution models under current and future climate conditions, and incorporate urban growth into these models, for all of the species to be addressed.

Publications

Page charges for one publication in an academic journal (e.g. Conservation Biology); 5 pages x \$150 per page = \$750 (page rate supplied by Conservation Biology website). Peer-reviewed work adds credence both scientifically and practically to the developed framework and its rigor.

Facilities and Administrative Costs

Indirect Costs (a.k.a. Facilities and Administrative costs) were estimated in accordance with UC Riverside's approved indirect cost rate agreement with the Department of Health and Human Services (DHHS), dated January 30, 2009, the Federal Cognizant Agency for UC Riverside. As of July 1, 2009, the applicable indirect cost rate for the proposed period is 52% Modified Total Direct Costs (MTDC,) which is the on-campus Organized Research rate appropriate for this project, and excludes the graduate student fees and tuition, the cost of the proposed equipment and subawards beyond the first \$25,000 per the rate agreement.

In kind

In-kind of 1 month summer salary with benefits is provided for Regan (\$10,606), Anderson (\$8,703) and Franklin (\$18,710). Regan and Anderson will construct population models for species for which models need to be developed and oversee the linking of population models with the species distribution models. Franklin will assist in development of SDM with and without climate change and urban growth. They will also provide direction and guidance for the postdoc on the management strategies implemented in the models.

In-kind time is also provided by the agency partners. Greer and Moore (both at SANDAG) will contribute 50 hours (at \$5,217) and 100 hours (at \$7,104) respectively to assist in development of management alternatives. Clark (Carlsbad Fish and Wildlife Office) will devote 2 weeks of time to assist in the development of decision support tools relevant to the actual needs of land and resource managers and policy makers (verified in the letter of support but no dollar amount specified so not included in budget spreadsheet).

Regan, Anderson and Franklin will also provide office supplies (\$500), as needed, as "in-kind" from their initial complement funds. They already have the equipment and licenses for all propriety software necessary to carry out this work.



United States Department of the Interior

FISH AND WILDLIFE SERVICE

Ecological Services
Carlsbad Fish and Wildlife Office
6010 Hidden Valley Road, Suite 101
Carlsbad, California 92011



In Reply Refer To:
FWS-SDG-FWS-11B0225-11TA0365

APR 08 2011

Memorandum

To: Science Coordinator, California Landscape Conservation Cooperative
Sacramento, California

From: Deputy Field Supervisor, Carlsbad Fish and Wildlife Office
Carlsbad, California 

Subject: Landscape Conservation Cooperative Climate Change Proposal: Decision Support for
Climate Change Adaptation and Fire Management Strategies for At Risk Species in
Southern California

The Carlsbad Fish and Wildlife Office (CFWO) supports the proposed research project "Decision support for climate change adaptation and fire management strategies for at risk species in southern California" and proposes to partner in the development of the project and its products.

CFWO recognizes the challenge that climate change and fire poses to decision makers for the management of threatened, endangered, and at risk species. In response to the anticipated effects of climate change and the altered fire regimes that are predicted to occur, managers will benefit from a better understanding of the impacts climate change will have on species distributions and thus make informed decisions that impact the most vulnerable taxa in fire-prone ecosystems. Information generated from this proposal can be used in the structured decision making process. We expect that the proposed project will help guide decision makers directing limited management funds, in the most efficient manner possible, when responding to climate change.

CFWO will support the proposed research with 2 weeks of staff time to participate in development of decision support tools relevant to actual needs of land and resource managers and policy makers. We expect that the products produced by the proposed research will provide needed and useful information that can be incorporated into on the ground management and recovery efforts.

TAKE PRIDE[®]
IN AMERICA 

April 6, 2011

Dr. Helen Regan
Associate Professor
Department of Biology
University of California
Riverside, CA 92521

Dear Dr. Regan,

I look forward to the opportunity to work with you on the project, "Decision support for climate change adaptation and fire management strategies for at risk species in southern California," for the California Landscape Conservation Cooperative. I am a landscape ecologist and geographer with more than 20 years experience working in California's terrestrial habitats. I have considerable expertise in species distribution models (SDMs), disturbance (fire) regimes and the dynamics of ecological communities. We currently collaborate on NSF-, DOE- and Dept of Defense-funded projects on the effects of climate change, altered fire regime and habitat fragmentation on plant functional groups in southern California.

Working closely with you and the other project personnel, I will construct SDMs for the study species using rigorous and appropriate methods and data, project those models of suitable habitat using future climate scenarios, and link those dynamics habitat suitability maps to your population models. I will also work with you to provide direction and guidance for the post-doctoral researcher on the management strategies implemented in the models. I will assist you in coordinating with our partners, policy makers and habitat managers from agencies, writing papers, and in the process of making our data products, recommendations and framework available to those partners.

I will provide an in-kind contribution of my assigned research time equivalent to one month of summer salary (including fringe benefits).

Sincerely,



Janet Franklin, Professor
School of Geographical Sciences and Urban Planning, and School of Life Sciences
e-mail: janet.franklin@asu.edu
Office Phone: (480) 965-9884; Dept Fax: (480) 965-8313



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April 8, 2011

File Number 3200100

Dr. Helen Regan
 Associate Professor
 Department of Biology
 University of California
 Riverside, CA 92521

MEMBER AGENCIES

Cities of
 Carlsbad
 Chula Vista
 Coronado
 Del Mar
 El Cajon
 Encinitas
 Escondido
 Imperial Beach
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 National City
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 San Marcos
 Santee
 Solana Beach
 Vista
 and
 County of San Diego

ADVISORY MEMBERS

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 California Department
 of Transportation
 Metropolitan
 Transit System
 North County
 Transit District
 United States
 Department of Defense
 San Diego
 Unified Port District
 San Diego County
 Water Authority
 Southern California
 Tribal Chairmen's Association
 Mexico

Dear Dr. Regan:

I look forward to the opportunity to work with you on the project, "Decision support for climate change adaptation and fire management strategies for at-risk species in Southern California," for the California Landscape Conservation Cooperative.

The San Diego Association of Governments (SANDAG), as a regional council of governments, has been assisting the local governments and state and federal wildlife agencies with implementation of regional conservation management and monitoring. SANDAG assistance comes from both the facilitation and coordination of land managers and monitoring research, as well as providing directed funding for addressing information gaps. SANDAG has previously collaborated successfully with your research group on developing regional conservation monitoring methods leading to several key insights and published articles. I anticipate that your proposed project will be very synergistic with our objectives, and that we and our partners can identify for you feasible alternative management scenarios and case studies for which your proposed decision support framework can directly contribute to our conservation management and monitoring goals.

Ms. Yvonne Moore, formally of the California Department of Fish and Game, has been contracted by SANDAG as the regional management and monitoring coordinator. She will be the most appropriate person to coordinate the science with the needs of the land managers for San Diego County, and she and I will look forward to working with you on this.

This coordination is equivalent to an in-kind contribution of 100 hours (\$7,104) of Ms. Moore's time and 50 hours of my time (\$5,217).

Sincerely,

KEITH A GREER
 Senior Environmental Planner
 Land Use and Transportation Planning

KGR/hob

Helen May REGAN - CURRICULUM VITAE

Biology Dept., University of California, 900 University Ave, Riverside, CA 92521.
Phone: 951-827-3961, Fax: 951-827-4286, Email: helen.regan@ucr.edu

University Education

1993 – 2000. PhD in Applied Mathematics, The University of New England, Armidale, NSW 2351, Australia.

1988 – 1992. Bachelor of Science (1st class Hons). Major: Applied Mathematics. Latrobe University, Australia.

Recent Career History

July 2007 – present. Assistant & Associate Professor, Biology Dept, University of California Riverside, CA, USA.

Jan 2003 – June 2007. Assistant Professor, Ecology Program, Biology Department, SDSU, CA, USA

Dec 2000 – Oct 2002. Postdoctoral Research Fellow, NCEAS, UCSB, CA, USA

Selected synergistic activities

2011-present. Member, Committee on Independent Scientific Review of Everglades Restoration Progress (CISRERP), The National Research Council, The National Academies.

2006-present. Member of the Standards and Petitions Working Group, Biodiversity Assessments Subcommittee of the IUCN Species Survival Commission.

2007. Invited participant. IUCN Climate Change workshop. Imperial College, Silwood Park, UK. August 27-31.

2002-2004. Member of the working group *Setting priorities and making decisions for conservation risk management* at the National Center for Ecological Analysis and Synthesis, University of California Santa Barbara, CA.

Selected publications (out of 54 total)

Syphard, A.D., K.C. Clarke, J. Franklin, **H.M. Regan**, and M. McGinnis. Forecasts of Habitat Loss and Fragmentation Due to Urban Growth are Sensitive to Input Data Quality and Scale. (In press *Journal of Environmental Management*)

Franklin, J., **H.M. Regan**, L.A. Hierl, D.H. Deutschman, B.S. Johnson, and C.S. Winchell. Planning, implementation and monitoring of multiple species habitat conservation plans. *American Journal of Botany* 98:559-571, 2011.

Lawson, D. M., **H.M. Regan**, P.H. Zedler and J. Franklin. Cumulative effects of land use, altered fire regime and climate change on persistence of *Ceanothus verrucosus*, a rare, fire-dependent plant species. *Global Change Biology* 16(9):2518–2529, 2010.

Regan, H.M., J.B. Crookston*, R. Swab*, J. Franklin, and D.M. Lawson. Habitat fragmentation and altered fire regime create trade-offs for the persistence of an obligate seeding shrub. *Ecology* 91(4):1114-1123, 2010.

Keith, D.A., H.R. Akçakaya, W. Thuiller, G.F. Midgley, R.G. Pearson, S.J. Phillips, **H.M. Regan**, M.B. Araújo, T.G. Rebelo. Predicting extinction risks under climate change: a new mechanistic approach linking stochastic population models with dynamic bioclimatic habitat models. *Biology Letters* 4:560-563, 2008.

Hierl, L.A., J. Franklin, D.H. Deutschman, **H.M. Regan**, and B.S. Johnson. Assessing and prioritizing ecological communities for monitoring in a regional habitat conservation plan. *Environmental Management* 42(1):165–179, 2008.

Regan, H.M., L.A. Hierl, J. Franklin, D.H. Deutschman, H.L. Schmalbach, C.S. Winchell and B.S. Johnson. Species prioritisation for monitoring and management in regional multiple species conservation plans. *Diversity and Distributions*, 14(4): 262-271, 2008.

Technical Reports to CDFG NCCP Local Assistance Grant #P0450009

Deutschman, D.H., L.A. Hierl, J. Franklin and H.M. Regan. 2007. Vegetation Community Monitoring Recommendations for the San Diego Multiple Species Conservation Program. 37 pp.

Hierl, L.A., J. Franklin, D.H. Deutschman, and H.M. Regan. 2006. Developing conceptual models to improve the Biological Monitoring Plan for San Diego's Multiple Species Conservation Program. 39 pp.

Franklin, J., L.A. Hierl, D.H. Deutschman and H.M. Regan. 2006. Grouping and prioritizing natural communities for monitoring in the San Diego MSCP. 50 pp.

Regan, H.M., L.A. Hierl, J. Franklin and D. Deutschman. 2006. Grouping and Prioritizing the MSCP Covered Species. 133 pp.

Hierl L., H.M. Regan, J. Franklin and D. Deutschman. 2005. Assessment of the Biological Monitoring Plan for San Diego's Multiple Species Conservation Program. 83 pp.

Education

Ph.D. 2004. The University of California, Santa Barbara. Ecology, Evolution, and Marine Biology.
B.S. 1997. Duke University. Major: Biology (with Distinction).

Recent Professional Experience

2009-Present Assistant Professor, University of California, Riverside, Department of Biology
2007-2009 Assistant Professional Researcher, University of California, Riverside
2005-2007 USDA NRI Post-doc, Florida State University, Department of Biological Science
2004-2005 Post-Doc, University of Calgary, Alberta Ingenuity Centre for Water Research, and University of California, Santa Barbara

Grants

Submitted. National Science Foundation. Modeling spatial population dynamics in branching river networks using quantum graphs (PI). \$459,318. Jonathan Sarhad, Co-PI.
2009-2010. Public Interest Energy Research Program, California Energy Commission. Integrating bioenergetics, spatial scales, and population dynamics for environmental flow assessments (Co-PI). \$138,400. Roger Nisbet, PI.
2009-2010. Naval Facilities Engineering Command. Technical assistance on the habitat fragmentation study in the vicinity of Naval Base Pt. Loma and MCAS Miramar. (PI). \$12,768.
2008-2009. Naval Facilities Engineering Command. Technical assistance on the habitat fragmentation study in the vicinity of Naval Base Pt. Loma and MCAS Miramar. (PI). \$7,842.
2005-2008. U.S. Dept. of Agriculture National Research Initiative Postdoctoral Fellowship, CSREES Award # 2005-35302-16997. Spatial population dynamics of pest herbivores on plants with inducible resistance: A theoretical framework. \$125,000.

Five Selected Peer-Reviewed Publications (out of 15 total)

Anderson, K.E., Inouye, B.D., and N. Underwood. 2010. Modeling herbivore competition mediated by inducible plant defenses. *Oikos*, **118**: 1633-1646.
Anderson, K.E., Nisbet, R.M., and Diehl, S. 2006. Spatial scaling of consumer-resource interactions in advection-dominated systems. *The American Naturalist* **168**: 358-372.
Anderson, K.E., Paul, A.J., McCauley, E., Jackson, L.J., Post, J.R., and R.M. Nisbet. 2006. Instream flow needs in streams and rivers: the importance of understanding ecological dynamics. *Frontiers in Ecology and the Environment* **4**: 309-318.
Fujiwara, M., **Anderson, K.E.,** Neubert, M.G., and H. Caswell. 2006. On the estimation of dispersal kernels from individual mark-recapture data. *Environmental and Ecological Statistics* **13**: 183-197.
Anderson, K.E., Rothstein, S.I., Fleischer, R.C., and A.L. O’Loughlen. 2005. Large scale movement patterns among song dialects in the Brown-headed Cowbird, *Molothrus ater*. *The Auk* **122**: 803-818.

Technical Reports

Nisbet, R.M., **Anderson, K.E.,** Pecquerie, L., and L.R. Harrison. 2011. Integrating bioenergetics, spatial scales, and population dynamics for environmental flow assessments. California Energy Commission, PIER. CEC-500-02-004.

Janet Franklin

**BIOGRAPHICAL SKETCH
JANET FRANKLIN**

EDUCATION

University of California, Santa Barbara	Environmental Biology, With High Honors	B.A., 1979
University of California, Santa Barbara	Geography	M.A., 1983
University of California, Santa Barbara	Geography	Ph.D., 1988

PROFESSIONAL EXPERIENCE

2009-present	Professor, School of Geographical Sciences, Arizona State University, Tempe, AZ
2006-2009	Associate Chair and Professor, Department of Biology, Adjunct Professor of Geography, San Diego State University (SDSU), San Diego, CA
2002-2009	Professor, Department of Biology, Adjunct Professor of Geography, SDSU, San Diego, CA
1995-2002	Professor, Department of Geography, SDSU.
1989-2002	Co-Director, Center for Earth Systems Analysis Research (CESAR), SDSU.
1992-1995	Associate Professor, Department of Geography, SDSU.
1988-1992	Assistant Professor, Department of Geography, SDSU.
1983-1984	Staff Scientist, Universities Space Research Association, Washington, DC.

Five refereed publications related to the proposal

- Franklin, J., 2009, *Mapping Species Distributions: Spatial Inference and Prediction*, Cambridge University Press, Cambridge, UK. ISBN 978-0-521-87635-3 338 pp.
- Franklin, J., 2010, Moving beyond static species distribution models in support of conservation biogeography, *Diversity & Distributions* 16(3): 321-330.
- Syphard, A. D. and Franklin, J., 2010, Species' functional type affects the accuracy of species distribution models for plants in southern California, *Journal of Vegetation Science* 21(1):177-189. (Both authors contributed equally to this paper.)
- Syphard, A. D. and Franklin, J., 2009, Differences in spatial predictions among species distribution modeling methods vary with species traits and environmental predictors, *Ecography* 32:907-918.
- Franklin, J., Wejnert, K., Hathaway, S., Rochester, C. and Fisher, R., 2009, Effect of species rarity on the accuracy of species distribution models for reptiles and amphibians in southern California, *Diversity and Distributions* 15: 167-177

Five other refereed publications (out of 100 total)

- Lawson, D. M., Regan, H. M., Zedler, P. H. and Franklin, J., 2010, Cumulative effects of land use, altered fire regime and climate change on persistence of *Ceanothus verrucosus*, a rare, fire-dependent plant species, *Global Change Biology* 16(9):2518-2529.
- Regan, H. M., Crookston, J. B., Swab, R., Franklin, J., and Lawson, D. M. 2010, Habitat fragmentation and altered fire regime create trade-offs for an obligate seeding shrub, *Ecology* 91(4):1114-1123
- Franklin, J, A. D. Syphard, H. He and D. Mladenoff, 2005, The effects of altered fire regimes on patterns of plant succession in the foothills and mountains of southern California, *Ecosystems* 8(8):885-898
- Franklin, J., 1998, Predicting the distributions of shrub species in California chaparral and coastal sage communities from climate and terrain-derived variables, *Journal of Vegetation Science* 9: 733-748.
- Franklin, J., 1995, Predictive vegetation mapping: geographic modeling of biospatial patterns in relation to environmental gradients. *Progress in Physical Geography* 19(4): 494-519.

Alexandra D. Syphard

Conservation Biology Institute, 10423 Sierra Vista Avenue, La Mesa, CA 91941
619-328-1001 asyphard@consbio.org

Education

- 1999 - 2005 San Diego State University and University of California, Santa Barbara
Ph.D., Geography, GPA: 4.0
- 1996 - 1998 Virginia Commonwealth University, Richmond, VA
Master of Interdisciplinary Studies, Environmental Science, GPA: 4.0
- 1993 - 1994 Medical College of Virginia, Richmond, VA
Master of Public Health, GPA: 3.8
- 1988 - 1992 University of Mary Washington, Fredericksburg, VA
B.A. English / communications, GPA: 3.3

Professional Experience

- 2007–current Conservation Biology Institute, San Diego, CA, Senior ecologist
- 2007 - 2008 Dept. Biology, San Diego State University, CA, Postdoctoral fellow
- 2005 - 2007 Dept. Forest Ecology, University of Wisconsin, Madison, WI Postdoctoral fellow
- 1999 - 2005 Dept. Geography, San Diego State University, CA Teaching Associate
- 1998 - 1999 VHB, Inc., Williamsburg, VA, GIS Analyst / Environmental Planner

Selected Relevant Publications

Syphard, A.D., Clarke, K.C., Franklin, J., Regan, H., and McGinnis, M. in press. Forecasts of habitat loss and fragmentation due to urban growth are sensitive to source of input data. *Journal of Environmental Management*

Syphard, A.D., Keeley, J.E., and Brennan, T.J. in press. Comparing the role of fuel breaks across southern California national forests. *Forest Ecology and Management*.

Syphard, A.D., and Franklin, J. 2010 Species' traits affect the performance of species' distribution models for plants in southern California. *Journal of Vegetation Science* 21: 177-189.

Syphard, A.D., and Franklin, J. 2009. Differences in spatial predictions among species distribution modeling methods vary with species traits and environmental predictors. *Ecography* 32: 907-918.

Syphard, A.D., Radeloff, V.C., Hawbaker, T.J., and Stewart, S.I. 2009. Conservation threats due to human-caused increases in fire frequency in Mediterranean climate ecosystems. *Conservation Biology* 23: 758-769.

Syphard, A.D., Radeloff, V.C., Keuler, N.S., Taylor, R.S., Hawbaker, T.J., Stewart, S.I., and Clayton, M.K. 2008. Predicting spatial patterns of fire on a southern California landscape. *International Journal of Wildland Fire* 17: 602 - 613.

Syphard, A.D., Radeloff, V.C., Keeley, J.E., Hawbaker, T.J., Clayton, M.K., and Stewart, S.I., Hammer, R.B. 2007. Human influence on California fire regimes. *Ecological Applications* 17: 1388-1402.

Syphard, A.D., Clarke, K.C., and Franklin, J. 2007. Simulating frequent fire and urban growth in southern California coastal shrublands, USA. *Landscape Ecology* 22: 431-445.

Clark S. Winchell – Biosketch

Education

1977 Bachelor's Degree Utah State University, Logan, Utah, USA. Major: Wildlife Science

Positions

Current:

1997 – present. Biological Monitoring Specialist (until 07 May 2011), U.S. Fish & Wildlife Service, Carlsbad Office, 6010 Hidden Valley Road, Carlsbad, CA 92011

Future:

Division Chief (starting 08 May 2011), Conservation Partnerships Program, U.S. Fish & Wildlife Service, Carlsbad Office, 6010 Hidden Valley Road, Carlsbad, CA 92011

Past:

1/1981 - 1/1985 Biologist/Data Analyst, Computer Sciences Corporation, San Diego, California, USA

10/1985 - 2/1989 Wildlife Biologist, Marine Corps Base Camp Pendleton, California, USA

2/1989 - 12/1996 Fish and Wildlife Biologist, Naval Air Station North Island, Coronado, California, USA

Peer-reviewed publications

Franklin, J., H. M. Regan, L. A. Hierl, D. H. Deutschman, B. S. Johnson, and C. S. Winchell. 2011. Planning, implementing, and monitoring multiple-species habitat conservation plans. *American Journal of Botany* 98:559-571.

Regan, H. M., L. A. Hierl, J. Franklin, D. H. Deutschman, H. L. Schmalbach, C. S. Winchell, and B. S. Johnson. 2008. Species prioritization for monitoring and management in regional multiple species conservation plans. *Diversity and Distributions* 14:462-471.

Winchell, C. S. and P. F. Doherty. 2008. Using California gnatcatcher to test underlying models in habitat conservation plans. *Journal of Wildlife Management* 72:1322-1327.

Groom, J. D., L. B. McKinney, L. C. Ball, and C. S. Winchell. 2007. Quantifying off-highway vehicle impacts on density and survival of a threatened dune-endemic plant. *Biological Conservation* 135:119-134.

Phillips, R. B., C. S. Winchell, and R. H. Schmidt. 2007. Dietary overlap of an alien and native carnivore on San Clemente Island, California. *Journal of Mammalogy* 88:173-180.

Winchell, C. S. 1999. An efficient technique to capture complete broods of burrowing owls. *Wildlife Society Bulletin* 27:193-196.

Mundy, N. I., C. S. Winchell, T. Burr, and D. S. Woodruff. 1997a. Microsatellite variation and microevolution in the critically endangered San Clemente Island loggerhead shrike (*Lanius ludovicianus mearnsi*). *Proceedings Of The Royal Society Of London Series B-Biological Sciences* 264:869-875.

Keegan, D. R., B. E. Coblentz, and C. S. Winchell. 1994. Feral goat eradication on San Clemente Island, California. *Wildlife Society Bulletin* 22:56-61.

Winchell, C. S. and S. G. Buck. 1992. Illegal harvest of spike bucks during a regulated mule deer hunt. *California Fish and Game* 78:153-159.

Winchell, C. S. and J. W. Turman. 1992. A new trapping technique for burrowing owls - the noose rod. *Journal of Field Ornithology* 63:66-70.

Wolfe, M. L., N. V. Debyle, C. S. Winchell, and T. R. McCabe. 1982. Snowshoe hare cover relationships in northern Utah. *Journal of Wildlife Management* 46:662-670.

KEITH A. GREER

EDUCATION:

Masters of Arts in Geography (30 units); San Diego State University. Concentration: Natural Resources and Environmental Quality.

Postbaccalaureate Studies in Ecology (27 units); San Diego State University.

Bachelor of Science in Marine Biology; California State University Long Beach.

EXPERIENCE:

Regional Environmental Planner, San Diego Association of Governments (2006 – Present)

- Implement strategy for \$440 m for advanced mitigation.
- Implementation of the \$880 m *TransNet* Environmental Mitigation Program.
- \$4 m management and monitoring strategy for regional conservation planning.
- Acquisition of land to meet the advanced mitigation needs of San Diego's Regional Transportation Plan - to date 676 acres totaling \$32 million.

Deputy Planning Director, City of San Diego City (2003 – 2006)

- Management responsibilities for five sections and 50 people.
- Management lead on \$9 m annual operating budget.
- Oversight on implementation of San Diego's regional habitat conservation plan.

Program Manager, City of San Diego Multiple Species Conservation Program (2001 - 2003)

Supervising Biologist, City of San Diego Multiple Species Conservation Program (1997 – 2001)

Environmental Planner, City of San Diego (1990 – 1997)

SELECTED RECENT PUBLICATIONS RELATED TO THE PROPOSAL:

K. Greer and M. Som. 2010. Breaking the Environmental Gridlock: advance mitigation programs for ecological impacts. *Environmental Practice* 12(3):227-236.

K. Greer and M. Johnson-Rocks. 2006. Rethinking regional Habitat Conservation Plan monitoring programs: An innovative approach in San Diego, California. *Endangered Species Update*. 23(3):91-95.

M. Klein and K. Greer. 2006. Smart Growth in San Diego, California: "America's Finest City" Locates Potential Growth Areas with GIS. *ESRI ArcNews*. Fall 2006. Vol. 28(3).

K. Greer and H. Cheong. 2005. What it takes to protect a rare plant in an urban environment. *Fremontia* 33(1):18-22.

M. White and K. Greer. 2005. The effects of watershed urbanization on stream hydrologic characteristics and riparian vegetation of Los Peñasquitos Lagoon, California. *Landscape and Urban Planning* 74(2):125-138.

K. Greer. 2004. Habitat Conservation Planning in San Diego County, California: Lessons learned after five years of implementation. *Environmental Practice* 6(3):230-239.

K. Greer and D. Stow. 2003. Vegetation type conversion in Los Peñasquitos Lagoon: an examination of the role of watershed urbanization. *Environmental Management*. 31(4):489-503.