Development of Reserve-Level Species and Habitat Monitoring Strategies:

Workshops and scientific support for monitoring in an adaptive management context.

Final Report

Natural Community Conservation Planning Program
Local Assistance Grant #P0982020
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EXECUTIVE SUMMARY

In recent years, significant progress has been made in the San Diego region on monitoring and management of species and natural communities. The Institute for Ecological Monitoring and Management (IEMM) at San Diego State University (SDSU) was funded by a CDFG LAG grant combined with a larger grant from SANDAG's Environmental Mitigation Program to provide direct support to preserve-level managers and planners to continue to strengthen and improve these monitoring and management activities at specific preserves within the MSCP. Products and activities for each of the six Tasks are described below.

Task 1

For Task 1, the IEMM team **reviewed all current and past land management documents** and actions for selected reserves. Introductory meetings and site visits were held with land managers from selected preserves to identify needs that might intersect with our scope of work and benefit from collaboration with IEMM. Examples of identified activities included: assisting the City of Chula Vista with identifying preserve level monitoring activities that would capture elements of climate change; providing monitoring guidelines for a project on cattle grazing to manage for burrowing owls at DFG's Rancho Jamul reserve; and providing scientific support for design and analysis of experiments by CBI at Crestridge and by CNLM in Carlsbad on control of invasive grasses to promote rare plants. IEMM also **convened a workshop** in November 2011 **on how to develop goals and objectives to improve monitoring and management**. This workshop was well attended and provided the opportunity for different stakeholders (managers, planners, rangers, etc.) to work together in small groups to develop specific goals and objectives for a number of management issues. Feedback from the workshop was overwhelmingly positive and participants indicated high interest in participating in similar events in the future.

Task 2

The initial focus of this task, adaptive management of tri-colored blackbirds at Rancho Jamul Ecological Reserve (RJER) was delayed, and thus focus shifted to support an **experiment on the sensitivity of Quino Checkerspot (*Euphydryas editha quino*) larvae to a commonly used herbicide (Fusilade®)**. The Quino experiment was started in the summer of 2011 after purchasing the larvae from Gordon Pratt at UC Riverside. Unfortunately, many of the larvae went into a secondary diapause. As a result, we don't have data on pupation success (though we have larval weights throughout the experiment). The most important measure of success is the successful emergence after pupation. We will continue the experiment in 2012 when the larvae break diapause.

Task 3

Task 3 focused on the topic of relevance of **conceptual approaches to reserve level monitoring**. Dr. Deutschman **presented a seminar to DFG staff in Sacramento** on the importance and utility of conceptual models as an integral part of the adaptive management framework. IEMM also **convened a workshop on developing conceptual models for management** in February 2012. Similar to the Goals and Objectives Workshop (Task 1), this workshop provided the opportunity for a number of stakeholders (managers, planners, and researchers) within the San Diego County MSCP to come together and develop conceptual models for a variety systems relevant to the region (i.e., California least tern, Hermes copper butterfly, Thread-leaved brodiaea, California coastal sage scrub, and

recreational trails and access control). This broad range of topics allowed participants to apply their experience and expertise to a species or system that had direct relevance to them. The range of topics also provided insight into how the conceptual model process works for species or systems in different stages of available knowledge and active management. Since the species and systems we used in this process are all in different stages in terms of available knowledge, management strategies, and monitoring programs, each group came away with different take home messages and emerging themes regarding how their models could and should be used for prioritizing management actions and addressing critical uncertainties. In addition, the workshop provided a forum for communication and participation that will improve the likelihood that these models will be adopted and used for guiding monitoring and management. Again, feedback from workshop participants was largely positive.

Task 4

An **external review of IEMM's activities** will be conducted on May 16-18, 2012 to meet this objective. The external review will be conducted by three independent scientists who represent a wide range of experience (academia, research institute, agency) who are highly qualified to review our work (see Appendix 7 for CVs). These scientists are supportive of, or engaged in, applied conservation science, have a strong publication record, and are engaged in academic:agency partnerships.

Task 5

As part of the preserve-level work, IEMM has been involved in **providing technical assistance for monitoring and management to a number of different projects and agencies within the MSCP**. These beneficial collaborations have created opportunities to integrate the wide ranging expertise of planners, managers, and biologists at preserves with the scientific expertise of the IEMM team. Examples of recent collaborations include developing a restoration plan and vegetation monitoring protocol for California least tern nesting habitat at Mission Bay Park, providing data analysis support for factors impacting burrowing owl presence at artificial burrows, providing monitoring support for utilizing cattle grazing to manage burrowing owl habitat at Rancho Jamul Ecological Reserve, and analyzing data on invasive grass control experiments at Crestridge Ecological Reserve.

Task 6

Adaptive management is driven by effective and efficient monitoring and management, supported by an iterative process by which monitoring data can be used to inform and guide management. **This report documents all the activities in which the IEMM has engaged in support of the adaptive management process.** Improving the adaptive management process has been the focus of work at the local, regional and national level and continues to challenge resource and land-use management and planning. The work conducted by IEMM served to strengthen the adaptive management process in the MSCP by supporting focused preserve-level work (decentralized, site-specific activities) as well as engaging in more community-focused (centralized) training exercises for a wide range of stakeholders.

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INTRODUCTION

San Diego's Multiple Species Conservation Program (MSCP) is a comprehensive Natural Community Conservation Plan (NCCP) and Habitat Conservation Plan (HCP) developed with the goal of conserving native vegetation communities and associated species in a nearly 2,500-square-kilometer area in southwestern San Diego County. The reserve system currently includes over 500 square kilometers of land. Monitoring and management responsibility for this large network of land lies with multiple jurisdictions, particularly the County and City of San Diego, participating Federal and State agencies such as U.S. Fish and Wildlife Service (USFWS), California Department of Fish and Game (CDFG), and U.S. Geological Survey (USGS) as well as multiple non-governmental organizations (NGOs) like TNC, Audubon, the center for natural lands management (CNLM), conservation biology institute (CBI) and the endangered habitats league/conservancy (EHL and EHC).

Context for this Project

In the San Diego region, several Natural Community Conservation Plans (NCCPs) have been adopted including the Multiple Species Conservation Program (MSCP; in the south). Four key elements of NCCPs must be integrated for an NCCP to successfully provide for the conservation of covered species. These elements are:

1. Reserve system assembly
2. Monitoring of species, habitats and ecosystem function at a broad regional scale
3. Monitoring of species, habitats and ecosystem function at a reserve level, to inform land managers of when and why any changes in management may be warranted
4. Implementation of effective management on reserve lands

The implementation of monitoring and management programs for NCCPs (steps 2-4) requires ongoing refinement based on analysis of the data collected, improved scientific methodologies, prioritization and evaluation of management activities. While significant progress has been made in the San Diego region on how to prioritize and conduct regional monitoring of species and natural communities, there is still much to be learned about how to do effective and efficient reserve level monitoring and how to implement successful management programs. This LAG has elements that are specific to improving monitoring and management in the MSCP (San Diego) but also address some common challenges facing NCCPs.

The nature of this project is outlined in the Scope of Work (SOW) and reflects input from US FWS, CA DFG, and SANDAG as well as other local and regional stakeholders. The work for the project has been conducted by a team of scientists at the Institute for Ecosystem Monitoring and Management (IEMM) at SDSU. For this project, this team was composed of SDSU professors (principally Drs. Lewison and Deutschman), postdocs, graduate and undergraduate students and SDSURF employees (collectively referred to as the IEMM team).

LAG and SANDAG Support

Most of the tasks for this LAG project are jointly funded by this LAG combined with a larger grant from SANDAG through its TransNet Environmental Mitigation Program (EMP). Over the two-year contract period, approximately 85% of the salary money for the IEMM team comes from the SANDAG EMP grant. The two projects were intended to have identical start and end dates. Unfortunately, the SANDAG grant was delayed and was finalized 10 months after the LAG grant. As a direct result, some of the tasks were delayed.

This project is part of a larger initiative to support adaptive management in the San Diego MSCP. Adaptive management is based on the fundamental idea that monitoring and management is an iterative process. The work conducted by IEMM was guided by an ad hoc steering committee with members from the wildlife agencies, government agencies and jurisdictions, as well as representatives from NGOs. During the initial phase of this project, some of the tasks were modified to meet the pressing needs of the monitoring and management community. These modifications represent that importance of inter-organizational collaboration and shared governance. Changes to the tasks are outline below (Table 1).

Table1: Revisions to the SOW in response to guidance from an *ad hoc* steering committee.

Task	Description from SOW	Modifications (if any)
1	Documentation of Current and Past Land Management Actions on NCCP Reserve Lands: *- Work with land managers from selected preserves* *- Host a workshop on refining goals and objectives*.	**Unchanged**
2	Implementation of Tricolored Blackbird Adaptive Management: *- Fill the tricolored blackbird nesting pond at RJER* *- Develop a monitoring program for this AM action*	**Revised:** Used to purchase endangered Quino (QCB) larvae for experiment on possible harm from herbicide exposure
3	Development of Conceptual Approaches to Reserve Level Monitoring: *- Develop a conceptual model* *- Conduct workshops*	**Largely unchanged:** Conceptual models were developed with multiple stakeholders. Additional workshops were not possible due to time constraints.
4	Independent Scientific Input: *Solicit expertise from independent scientists to review products associated with reserve level monitoring and adaptive management*	**Unchanged, but delayed:** Scheduled for May 16 & 17, 2012
5	Technical Assistance for Reserve Level Monitoring and Adaptive Management: *Help land managers implement AM and monitoring*	**Unchanged**
6	Summary of Activities and Final Report	**Unchanged**

TASK 1: CURRENT AND PAST ADAPTIVE MANAGEMENT

Task 1 focused on two main deliverables. The first deliverable is documentation of the collaborative work IEMM has engaged in with focal preserves within the MSCP. The goal of the collaborative preserve-level work was to provide direct support for and to improve ongoing monitoring and management at preserves. The second deliverable provides more general support for a wider community of stakeholders engaged in monitoring and management. The workshop, held in November 2011, was designed to provide training and guidance on the first critical step in adaptive management – how to develop and use goals and objectives to improve monitoring and management.

Collaborative Work with Focal Preserves

A primary goal of this grant was to provide direct support to preserve-level managers and planners to help strengthen and improve monitoring and management activities at specific preserves within the MSCP. To identify which preserves would be best suited for this project, we established an ad hoc steering committee comprised of scientists, managers, and regulators from several agencies including SANDAG, US FWS, CA DFG, City and County of San Diego, City of Carlsbad, The Nature Conservancy, and SDMMP. The ad hoc steering committee met in September 2011 and identified a list of seven focal preserves or preserve complexes (See Figure 1). In preparation and subsequent to that meeting, the IEMM team collated all current management and/or resource plans, compiled baseline and monitoring data, and synthesized recent or ongoing management actions at these focal preserves.

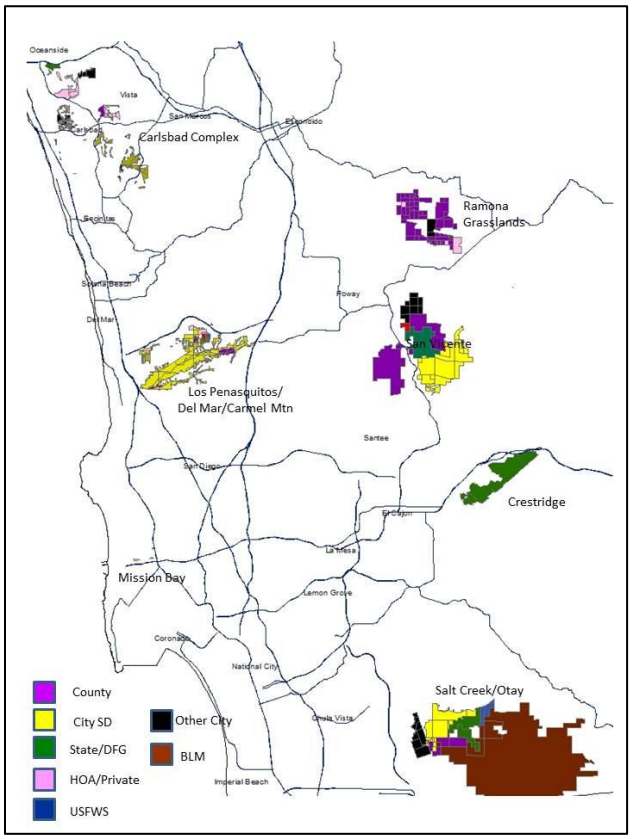

Figure 1: Focal preserves based on discussions with our *ad hoc s*teering committee.

Guided by the ad hoc steering committees recommendations, we contacted managers and management organizations for each of the preserves (Table 2). As part of our initial preparation for this process, we compiled more than 50 relevant documents, studies and data for the focal preserves (Table 3). A compilation of these documents had not been done to date and proved to be somewhat challenging because of the large number of jurisdictions, agencies, and individuals working in and around the MSCP.

We then held introductory meetings with land managers from each preserves to discuss their management and monitoring needs and identify potential collaborative projects that met preserve-level needs, fit the scope of work, and could support adaptive management in the preserve. We conducted follow-up site visits to each reserve to assess these areas of collaboration in more detail. These initial meetings, site visits, and follow-up work on specific areas of collaboration are identified in Appendix 1, which documents over 25 preserve level meetings and activities. Examples of these activities include: assisting the City of Chula Vista with identifying preserve level monitoring activities that would capture elements of climate change; providing monitoring guidelines for a project on cattle grazing to manage for burrowing owls at DFG's Rancho Jamul reserve; and providing scientific support for design and analysis of experiments by CBI at Crestridge and CNLM in Carlsbad on control of invasive grasses to promote rare plants. This level of engagement and partnership also provided opportunities for the IEMM to work with preserve partners on directly improving management documents. For example, IEMM reviewed and is working with the City of San Diego on improving the draft resource management plan for Mission Trails Regional Park, which was identified as a key need by the City of San Diego DPR. Similarly, the IEMM engaged in a review process with the City of Chula Vista to improve their annual management workplan documents.

Table 2: Agencies and land managers for focal preserves.

Preserve/Preserve complex	**AGENCY/MANAGER**
Crestridge	DFG/EHL
Carlsbad complex	City of Carlsbad/ CNLM
San Vicente OSP	DFG/County of San Diego
Goodan Ranch/ Sycamore Canyon	County of San Diego
Boulder Oaks OSP	County of San Diego
San Vicente Cornerstone Lands	City of San Diego Public Utilities
Iron Mtn	City of Poway
Los Penasquitos	City San Diego DPR
Carmel Mountain/ Del Mar Mesa	City of San Diego DPR /DFG
Otay Lakes	City San Diego Public Utilities
Otay Ranch - Salt Creek and San Ysidro Preserves	City of Chula Vista
Otay Mountain	BLM
Ramona Grasslands	County of San Diego
Mission Bay	City of San Diego DPR

Table 3: Examples of documents and data relevant to the focal preserves
(full table in Appendix 2)

Potential Preserve Name (Owner/Mgr)	Relevant documents In Hand	Documents we have seen referenced but do not have
Crestridge (DFG/EHL)	• Final Draft HMMP 2009 • County MSCP Monitoring Report 1998-2007	
Carlsbad complex (City Carlsbad/ CNLM)	• PMP 2008 (Carlsbad) • HMP 2004 (Carlsbad) • AR 2009 (Carlsbad) • AR 2010 (Carlsbad) • PMPs and 2010 AR for CNLM managed lands • PMP and 2010 AR for Emerald Pt • 2010 AR for Buena Vista ER (CNLM)	• Batiquitos 2003 Draft MP • Buena Vista MP
Regional or multi-preserve specific	**Regional/ multi-preserve surveys (candidate preserves that are included are listed below):** - 2002-2003 arroyo toad and western pond turtle county wide (multi-county) - 2001 CAGN survey – Lake Hodges, Black Mtn, Los Penasquitos, Mission Trails - 2006 CAGN region-wide occupancy study - 1999 Quino survey – Otay Lakes, Mission Trails, San Vicente - 2000 Quino survey – Otay Lakes, Mission Trails, Lake Hodges - 2003 Quino survey – Otay Lakes and Mission Trails - 2003 countywide raptor survey (most locations above) - 2003 vernal pool inventory – Mission Trails and Otay Lakes - County MSCP monitoring overview 1998-2007 – Crestridge, San Vicente, 4S	

Goals and Objective Workshop

Goals and objectives serve as key foundations for effective monitoring and management. Goals are broad, concise visionary statements that set overall direction for monitoring and management. In contrast, objectives are concrete and measurable statements that detail how a specific goal can be attained. Recent reviews of published and established goals and objectives provide insight on the fundamental challenges in developing robust goals and objectives (Tear et al 2005, Schroeder 2006, 2009). Although these and a number of other documents discuss the importance of goals and objectives and provide general guidelines, developing and using robust goals and objectives remains a challenge to managers in the MSCP and nationally (Schroeder 2006). One of the challenges relates to the confusion in the definition of terms, e.g. how is a goal different than an objective. The other challenges relate to the complexity of capturing best-available science (which may be influenced by limited resources, time and/or expertise), a desire to maintain flexibility on the part of managers, and difficulty with concretely

quantifying change either in species or natural communities, or both. For all these reasons, lack of robust goals and well-articulated objectives continues to limit effective monitoring and management.

On November, 2, 2011, The Institute for Ecological Monitoring and Management (IEMM) hosted a day-long workshop that explored the importance and utility of robust goals and objectives to monitoring and management (See Appendices 3 and 4 for complete workshop proceedings). The meeting's 55 participants represented a diverse array of backgrounds and experience, including land/preserve managers, resource managers, biologists, planners, rangers, and regulatory agency staff. The purpose of the workshop was to provide an opportunity for the local land management community to come together and discuss the importance and difficulties of constructing effective goals and objectives in the context of monitoring and management. In particular, the workshop explored the challenges in developing goals and objectives that follow the specifications outlined in existing templates and guidelines on writing management plans (Paveglio and Taylor 2010, Adamcik et al 2004). The workshop focused on goals and objectives at the preserve level, while recognizing the importance of placing local goals and objectives in the broader regional context, concurrent work led by the San Diego Monitoring and Management Program (SDMMP) program.

In the first half of the workshop, the workshop participants met in plenary to review working definitions and criteria for goals and objectives. As a group, we also reviewed some current examples of goals and objectives for species and natural communities of conservation concern. In addition, we considered the importance of connecting preserve-level goals and objectives within a regional context. Finally, land managers from three different organizations shared their perspectives and personal experiences with writing effective goals and objectives.

IEMM presentation

In preparation for the breakout groups, the IEMM (R. Lewison and D. Deutschman) presented an overview of the importance of goals and objectives within the context of monitoring and management, the challenges faced when developing goals and objectives, and the utility and benefits of using SMART criteria (Figure 2). We also reviewed three relevant examples of species or natural communities that are actively managed in the San Diego region but pose different challenges in developing effective goals and objectives. We explored potential goals and objectives for each of these systems and assessed how well the objectives meet the SMART criteria.

SDMMP Presentation

Ron Rempel, Program Administrator for the San Diego Management and Monitoring Program, provided an overview of the Management Strategic Plan (MSP) being developed for the EMP Working Group (Figure 3). The MSP will provide guidance for implementation of regional level management in western San Diego County and will define goals and objectives for managing species and habitats at the regional level. During the presentation, reserve managers were encouraged to take into account the regional goals and objectives when developing specific goals and objectives for species and habitats that occur on their individual preserves.

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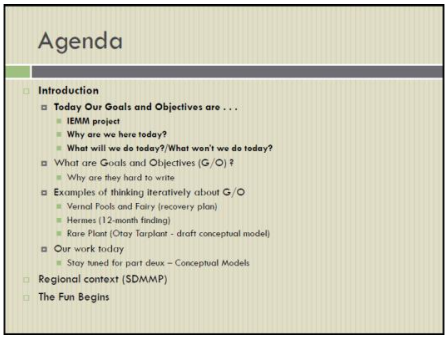

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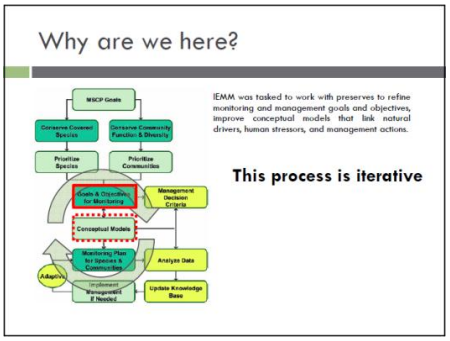

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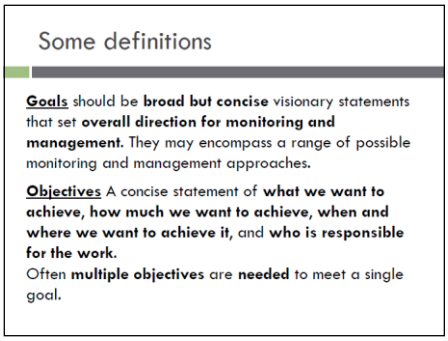

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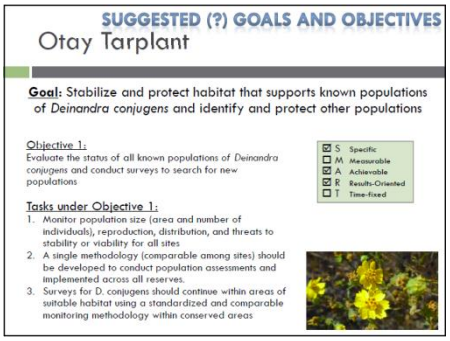

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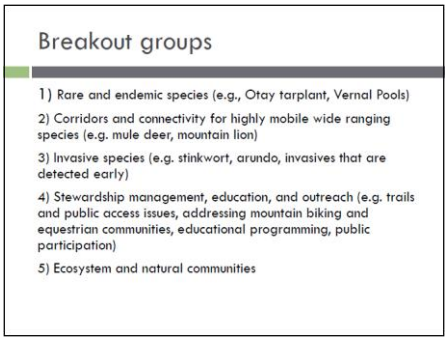

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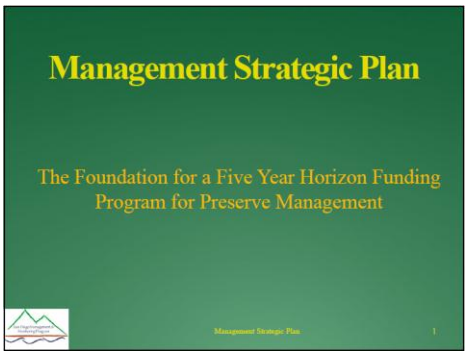
Figure 2: Excerpts from the IEMM presentation.



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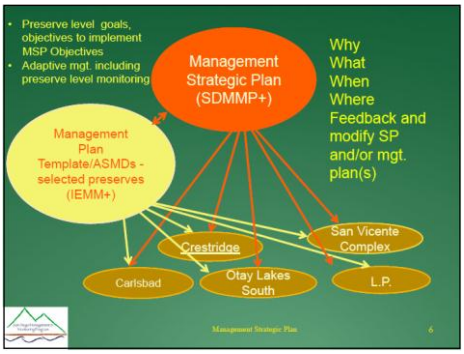

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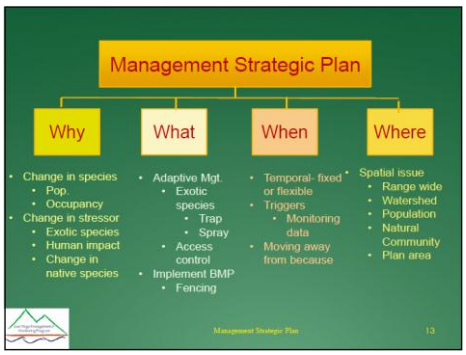

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Figure 3: Excerpts from the SDMMP presentation.

During the second half of the workshop, participants were asked to confront the challenges in developing goals and objectives by working collaboratively in small, focused working groups writing goals and objectives that met the SMART criteria. SMART is an acronym used by the US Fish and Wildlife Service (FWS; Adamcik et al 2004) that represents the key features of a robust objective, one that is

specific, **m**easurable, **a**chievable, **r**esults-oriented and **t**ime-fixed. In small breakout groups, workshop participants worked to write SMART goals and objectives.

Breakout Group Exercise

A primary focus of the workshop was to facilitate the exchange of ideas in smaller breakout groups. These groups were tasked with developing meaningful goals and specific and concrete objectives for species, communities, threats, and stressors that are relevant to San Diego County. Although the group exercise was designed to provide direct experience with goal and objective development, the ultimate purpose of the exercise was to give participants meaningful experience with the *process* of developing effective goals and objectives, rather than developing a list of objectives that would be directly adopted by managers. Topics were intended to be narrow enough to provide the opportunity for each group to create concrete goals and objectives, but broad enough to be relevant to managers across preserves.

Topics were chosen to represent a range of management issues, from monitoring of rare species to managing recreational use and access. The final breakout topics reflect feedback from the pre-workshop survey sent to invitees. Each group was asked to consider how their developed goals and objectives would need to be changed or modified when applied to different types of preserves (e.g., small vs. large preserve, isolated preserve vs. a preserve that exists as part of a network or preserve complex.).

The group topics were:

i. Rare and endemic species
ii. Wide-ranging species and connectivity
iii. Invasive species
iv. Stewardship management, education and outreach
v. Ecosystems and Natural Communities

Participants self-selected into groups by signing up for their first and second choice of topics. IEMM staff then assigned individuals to a group topic in order to assure fairly even group sizes and to ensure diversity of participants (e.g. rangers, biologists, regulators) within each group. Within the broad group topic, participants selected a narrower focal topic to develop specific goals and objectives. A list of management topics and focal species recommended by the EMP working group for SANDAG 2012 funding priorities were provided to the groups in order to facilitate topic choices that might reflect relevant management priorities.

IEMM staff acted as facilitators where needed, but the process was largely driven by group participants. Members of the group were asked to document the goals and objectives formulated and to provide a narrative which documented the assumptions and expert knowledge used in the development process. At the end of the workshop, each group gave a 5-10 minute presentation to all of the workshop participants, stating the goals and objectives their group developed as well as the points of discussion that were part of that development.

TASK 2 – SENSITIVITY OF LARVAL QCB TO HERBICIDES

In the initial proposal, Task 2 was intended to enhance the suitability of the habitat for the tricolored blackbird (TCB) at Rancho Jamul Ecological Reserve (RJER). Our role was to work with DFG land managers in identifying the appropriate timing for filling the tricolored blackbird nesting pond with water at RJER and assist, as requested by DFG, in the development and implementation of a TCBB monitoring program for this adaptive management action.

The intended collaboration on the adaptive management of TCB at RJER was delayed. At the same time, there was an urgent need to support an experiment on the sensitivity of Quino Checkerspot (*Euphydryas editha quino*) larvae to a commonly used herbicide. The experiment on Quino larvae was funded by DFG through a Cooperative Endangered Species Conservation Fund (Section 6) grant (P1082033). The budget for the Section 6 grant covered personnel and lab costs, but not for the purchase of thousands of larvae. After lengthy discussions with both DFG and FWS, we were directed to use the $25,000 budgeted for the cost of pumping water for TCB to pay $21,750 for Quino larvae.

Sensitivity of Quino larvae to Fusilade

The main objective of the experiment is to determine the sensitivity of Quino larvae to direct and indirect exposure to Fusilade®, the herbicide most widely used to manage Quino habitat. Since Fusilade is applied with a surfactant, it is essential to separate the potential effects of the surfactant from the effects of the herbicide itself (Figure X).

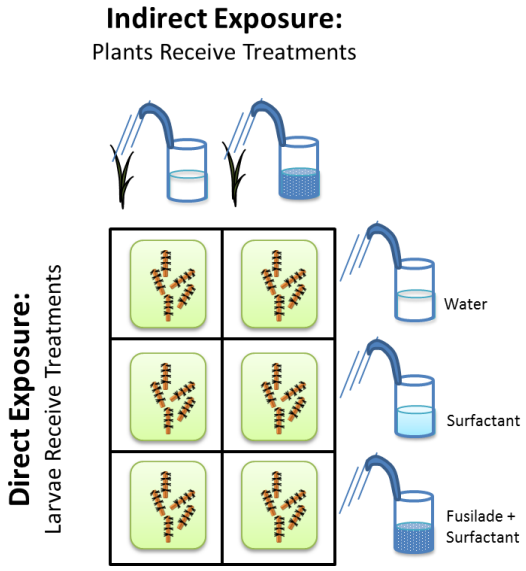

Figure 4: Schematic of the factorial experimental design. Note that we tested for both direct and indirect effects of the herbicide.

The Quino experiment was started in the summer of 2011 after purchasing the larvae from Gordon Pratt at UC Riverside. Unfortunately, many of the larvae went into a secondary diapause. As a result, we don't have data on pupation success (though we have larval weights throughout the experiment). The most important measure of success is the successful emergence after pupation. We will continue the experiment in 2012 when the larvae break diapause.

TASK 3: CONCEPTUAL MODELS

Conceptual models have been identified as a key part of the adaptive management framework (Gross 2003, WWF 2005, Heirl et al. 2007). These models can come in many forms from a basic narrative or flow chart, to a complex diagram with numerous inter-connected elements. All these types of models serve to formalize our current understanding of system processes and dynamics, identify critical linkages and relationships within the system, and identify the bounds of the system of interest. The process of model construction, evaluation and review facilitates the articulation of the assumptions of how we think a system works, provides us an opportunity to document the source of that knowledge (e.g. expert opinion, published research) , and helps direct future management, monitoring and research efforts by identifying critical sources of uncertainty. Conceptual models can also facilitate constructive communication among stakeholders with different expertise and experiences (e.g., scientists, land managers, rangers and planners).

Introduction

Our work on this task began with a seminar that Dr. Deutschman gave to DFG staff in Sacramento on the importance and utility of conceptual models as an integral part of the adaptive management and the NCCP process. This was part of Dr. Deutschman's activities with the John Muir Institute of the Environment at UCDavis. As a part of this work, Dr. Deutschman discussed the process of conceptual model building, re-visiting the work conducted by the Franklin et al LAG grant P0450009.

On February 29, the IEMM held a workshop for managers, planners, and researchers in the San Diego County MSCP on building and using conceptual models for management. The goal of the workshop was to provide participants with an understanding of the importance and utility of conceptual models for management as well as provide first-hand experience with model construction and review. Following a plenary presentation introducing conceptual models and the model-building process (see Appendix 6), participants divided into different working groups that focused on five subjects of conservation and management concern under the MSCP – California least terns (CLTE), Hermes copper butterflies (HCB), Thread-leaved brodiaea (TLB), California Coastal Sage Scrub (CSS), and recreational trails and access control (RTAC). This broad range of topics allowed participants to apply their experience and expertise to a species or system that had direct relevance to them. The range of topics also provided insight into how the conceptual model process works for species or systems in different stages of available knowledge and active management.

Conceptual models for management

Unlike a conceptual model that is being constructed to explore the biological or ecological mechanisms underpinning a natural system or species, conceptual models for monitoring and management are focused and tailored to address specific management issues. To be effective, conceptual models for management must ***establish a goal*** for the model, deal with ***model complexity***, and demonstrate a ***clear link between the model structure and management***. There a strong

Box 1: Creating effective conceptual models for management.

Gross (2003) identified 6 steps in creating an effective conceptual model for management:

- Clearly state the objective of the model
- Identify bounds of the system of interest
- Identify key model components, subsystems, and interactions
- Describe relationships of natural and anthropogenic stressors, ecological factors, and responses
- Articulate key questions and uncertainties or alternative approaches
- Review, revise, and refine models

Heirl et al. (2007) added 2 additional steps for incorporating management and monitoring strategies:

- Identify potential management responses for the relevant species or system
- Identify what to monitor based on the main parameters that link to the dynamics of the relevant species or community in the context of the monitoring goals

literature base that articulates what makes for an effective conceptual model for management (**see Box 1**). Here we build on that foundation and explore these topics in more detail.

Establishing a management goal

Goals and objectives serve as key foundation for effective monitoring and management and should be the first step in conceptual model development. Goal definition helps focus the model for management as well as identify which elements to include in the model (Manley et al. 2000). Goals are broad, concise visionary statements that set overall direction for monitoring and management. In contrast, objectives are concrete and measurable statements that detail how a specific goal can be attained. Often multiple objectives are needed to meet a single management goal. The step-wise process of goal setting has been articulated in a number of documents (Tear et al 2005, Schroeder 2006, 2009).

Model complexity

In constructing any model, the model builders are faced with the challenge of balancing brevity and clarity with complexity. Determining the appropriate level of model complexity of is one of the central challenges in conceptual model construction. All natural systems, whether a species like Hermes Copper or a system like Coastal Sage Scrub, have complicated dynamics and interactions. The challenge in constructing a conceptual model that can inform management is to identify which model elements are essential to describe system function. Likewise, model elements need to be screened in terms of their relevance for management. As part of the workshop, we explored the level of complexity that was necessary for each species or system of interest.

A conceptual model for monitoring and management should be only detailed enough to address the defined goals and objectives and provide answers to relevant questions (Gross 2003, Burgman 2005). In designing models for monitoring and management of ecological systems, less is definitely more. Particularly with species and systems that are not well understood, parsimonious models supported by available data are preferable to more complex models based on conjecture and opinion (Heirl et al. 2007). An example from the North Atlantic Commercial Fisheries Ecosystem (NACFE) illustrates the tradeoff between parsimony and complexity in developing conceptual models. The diagrams below illustrate an extremely complex model of the NACFE (~300 relationships among 90+ species; Figure 5A) to an exceedingly simple one (only trophic levels, no individual species are represented; Figure 5B). An extremely detailed model might be useful for visualizing the truly complicated nature of the system and for exhaustively identifying all elements in a system, but will likely be too muddled to clearly elucidate the critical relationships and processes in the system. Alternatively, an overly simplistic model might be elegant in depicting the key relationships and processes in a system, but is likely to miss important linkages and processes that are fundamental to managing the system. Highlighting or extracting relevant elements of a more complicated model that have direct relevance to management or are critical to system functioning is one way to generate a conceptual model that can provide guidance and inform monitoring and management.

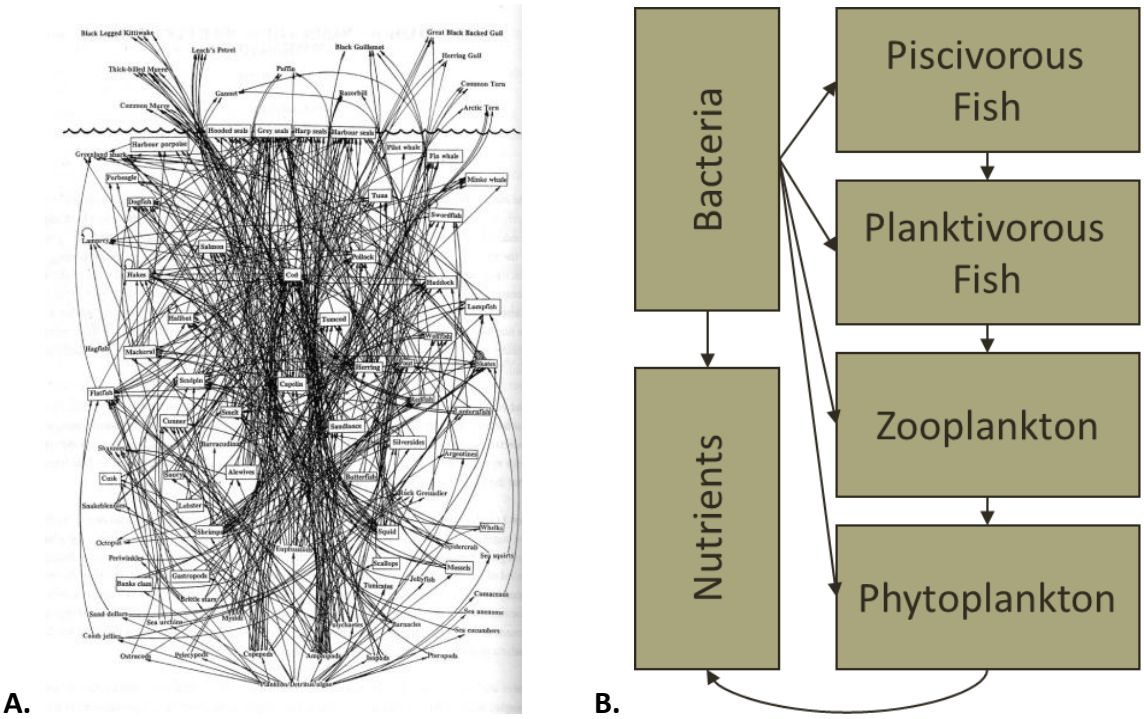

Figure 5: Two conceptual models of energy flow through the North Atlantic commercial fisheries ecosystem.

A. Complex model (Yodzis 1994.The trophodynamics of whole ecological communities. Pages 443-453 in SA Levin (ed) Frontiers in Mathematical Biology. Springer-Verlag) **B.** Simplified model of the same system (D Deutschman).

Anatomy of a conceptual model

What are the key elements of a conceptual model for monitoring and management? There are no definitively right or wrong components or elements in a conceptual model. What elements to include in any given model will depend on how much is known about the system and the stated management goal for the model. Figure 6 below illustrates a general example of a conceptual model in accordance with some established criteria (see Box 1 above). There are three key elements: anthropogenic drivers, natural drivers and the measurable response variables. In this example, anthropogenic drivers are listed on the left (red), natural drivers on the right (blue), and response variables in the center (green). The black lines indicated the relationship between drivers and the response variables. Model elements can be outlined or otherwise set apart to indicate monitoring targets, arrow thickness can be used to highlight and delineate the importance or strength of various relationships, and letters can serve as notation to indicate particular management actions.

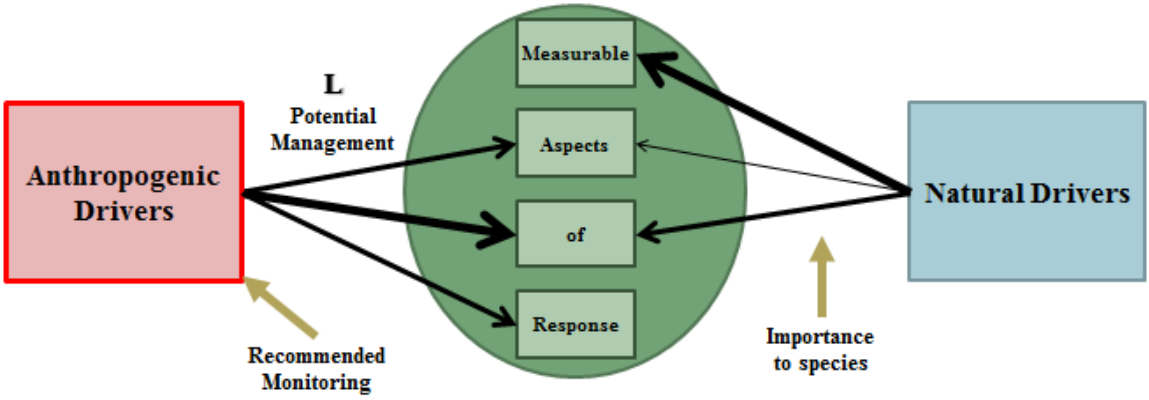

Figure 6: Anatomy of a conceptual model for adaptive management.

How can conceptual models inform management?

The process of developing and reviewing conceptual models can promote shared learning, support compromise and buy in among stakeholders, facilitate communication among experts with diverse knowledge bases as well as clarify system dynamics and element relationships, all of which serve to improve and inform management of the system. The stage of understanding and management of a given species or system will drive exactly how the model development process informs management. For example, CLTE have been actively managed and monitored for nearly 40 years. A conceptual model for the CLTE community of scientists and managers is instrumental in identifying gaps in knowledge and discussing/prioritizing critical uncertainties to determine how management and monitoring could and should be modified, streamlined, or more coordinated among sites and jurisdictions. For HCB, however, there is very little ecological or biological information known about the species. Monitoring for this species is just beginning and no management program is in place. A conceptual model in this case serves to formalize our understanding of how the system works and provides an opportunity to identify and prioritize a list of both immediate and longer-term research needs that can inform monitoring and management priorities.

For each species or system of focus, each group of experts and stakeholders can guide model development to meet their management needs. As part of this workshop, stakeholders were asked to use the best-available knowledge of their system to create and review conceptual models for management that described how their system worked, and identified monitoring actions, management targets and critical uncertainties that would best inform and improve the adaptive management process for these species and systems.

Workshop Planning and Structure

Prior to the workshop, IEMM gathered relevant background information for each group, including a thorough list of relevant literature, a narrative describing the key components of each system (based on the literature review), and developed draft models to serve as a starting point for discussion within groups (Appendix 5). The narrative included management and monitoring goals, natural drivers of the system, anthropogenic threats, species variables, monitoring targets, management actions, and critical uncertainties. Both the narrative and the draft models were designed not to serve as a distraction or limitation to the creativity of the participants, but rather to provide helpful guidance to the groups for the sake of time limitations at the workshop. In fact, only the narratives and bibliographies were sent out to participants beforehand so they could familiarize themselves with the information and edit pieces based on their knowledge and thinking about the system. The draft models were presented to the groups only after a thorough discussion of the model elements at the workshop and after participants had ample time to think about what a conceptual model of the system might look like to them. Many groups used the draft models as a starting point to edit and depict the relationships among model elements, while some groups started from scratch in generating their models.

The workshop was structured to maximize the amount of time that participants spent in their breakout groups. The schedule was presented to the participants as a table and then redrawn as a graphical conceptual model to emphasize how effectively graphic models can convey information.

Time	Task
09:15 – 09:30	Sign In
09:30 – 10:30	Presentation: Overview of Conceptual Models:
10:30 – 10:45	Break
10:45 – 11:45	Break Out Groups: Initial discussion about model
11:45 – 12:00	Reporting- Issues: Sharing ideas and/or concerns across groups
12:00 – 13:00	Lunch
13:00 – 14:30	Break Out Groups: Model development and refinement
14:30 – 14:45	Break
14:45 – 15:30	Break Out Groups: Finalized model and prepare for presentation
15:30 – 16:20	Group Presentations Each group makes a 5 min presentation
16:20 – 16:30	Final Discussion and Wrap Up

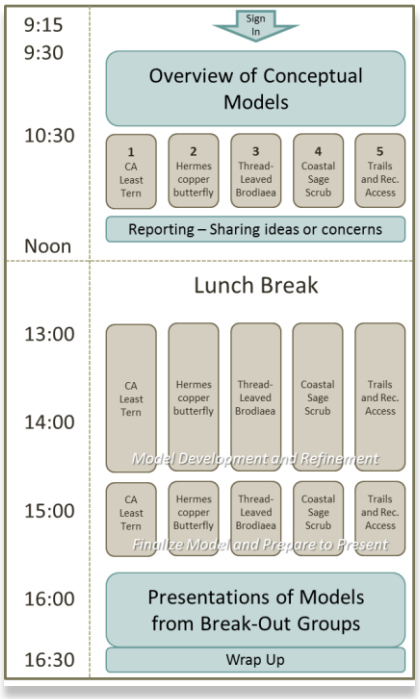

Figure 7: Workshop structure presented as a traditional table (left) and as a graphical conceptual model (right).

Workshop Results – Models

The final model(s) from each group consists of the graphical conceptual model, the literature used in the construction of the model, a table detailing the information sources for each model element, and a written narrative that explains the model and the key decisions made by each group (See Figure 8 for thumbnails of these elements for Hermes copper).

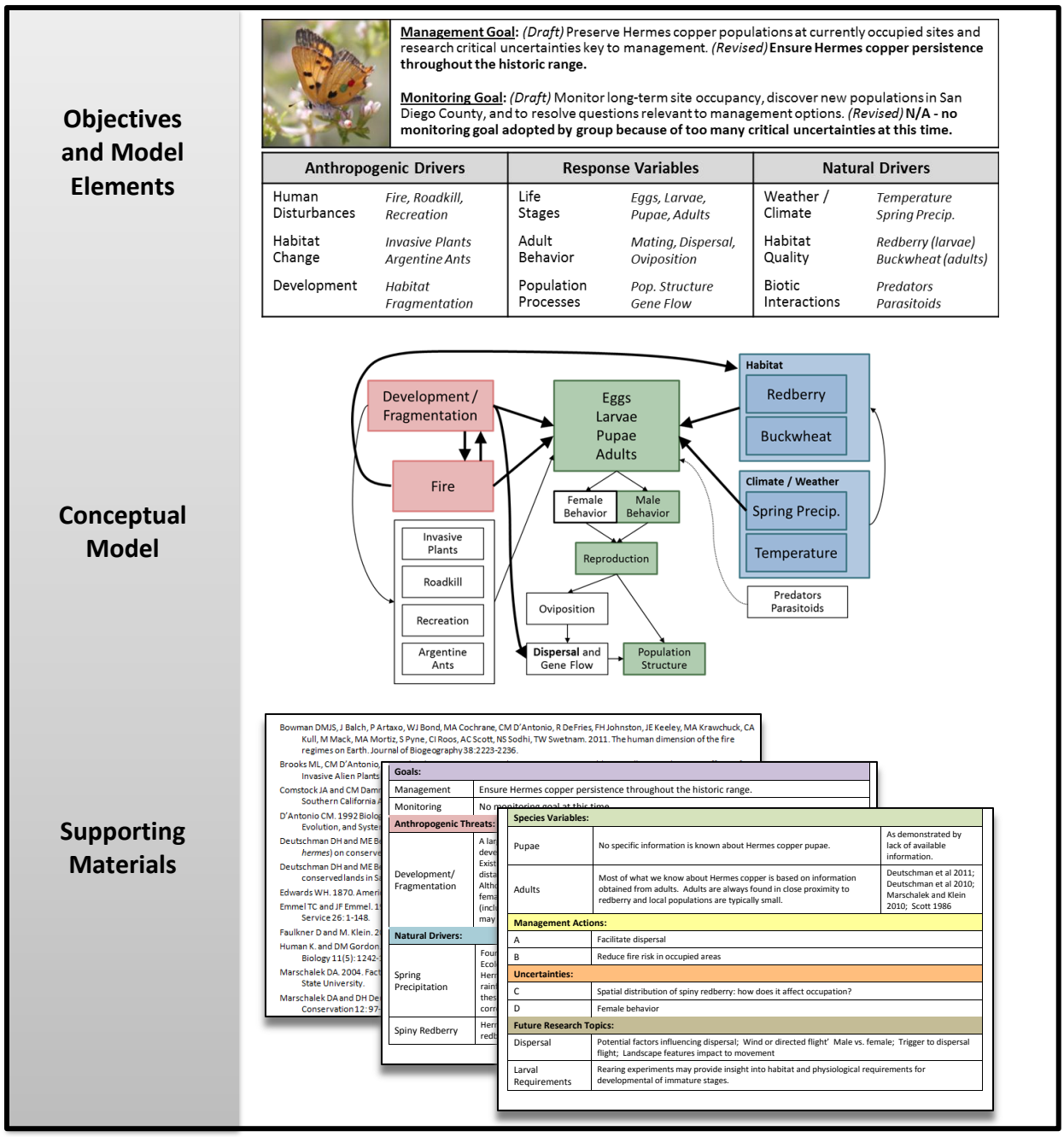

Figure 8: Elements for the Hermes conceptual model including model goal, model elements, the graphical model, supporting descriptions, and literature/data sources.

The process of constructing these models with a group of experts and stakeholders resulted in multiple benefits. The first benefit was that models were more relevant to the group participants. The participants often learned something about their system and the utility of conceptual models. In addition, the workshop provided a forum for communication and participation that will improve the likelihood that these models will be adopted and used for guiding monitoring and management. For example, the recreation group revised both the monitoring and management goal, added several drivers and response variables, and linked planning as a process to the authorized and unauthorized use submodel (Figure 9).

Management Goal: *(Draft)* Balance the protection of biological and cultural resources with recreational use. *(Revised)* **Maintain and enhance biological resources and protect cultural resources while allowing for sustainable recreation in appropriate places.**

Monitoring Goal: *(Draft)* Monitor the impacts of recreational use. *(Revised)* **Measure recreational use and how it is affecting biological and cultural resources.**

Anthropogenic Drivers		Response Variables		Natural Drivers	
Authorized / Unauthorized Use	*Equestrian, Biking Climbing, Hiking, Dogs, Hunting, Fishing*	Altered Resources	*Disturbance to: Wildlife, soil, and Vegetation Non-Native Species Water Quality*	Structure	*Slope and Aspect Topography Soil Characteristics Vegetation Comm.*
Unauthorized Use	*Vehicles*	Cultural Resources	*Disturb Cultural Resources*	Dynamics	*Weather/Climate, Hydrology, Fire*

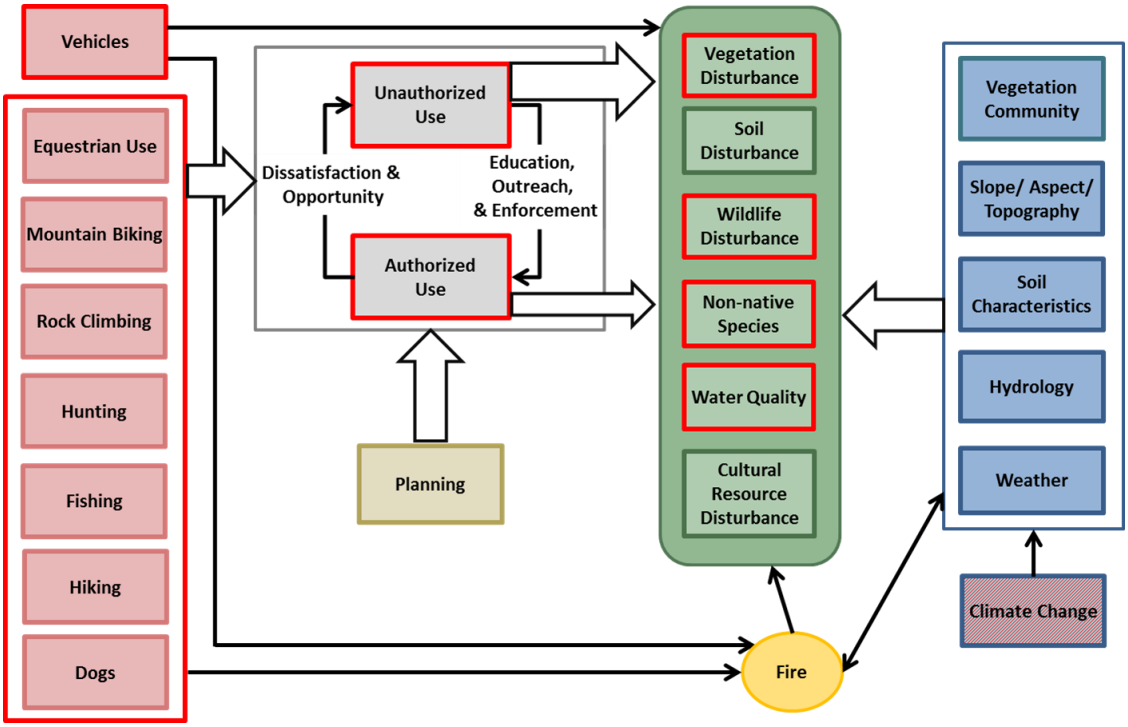

Figure 9: Definition of model elements and the graphical conceptual model from the recreation group.

Discussion of Workshop: Participant feedback

To assess the impact and efficacy of the workshop, we solicited feedback from workshop participants. We developed an online survey using Survey Monkey and asked participants to provide complete the survey after the workshop. More than 20 surveys were completed (response rate of 40%). In general, their feedback was quite positive and confirms that most participants felt the material was relevant (Figure 9). Between 80% and 90% of respondents rated the workshop 'excellent' and 'good' both in overall impression and in the relevance and utility of the material and the workshop activities.

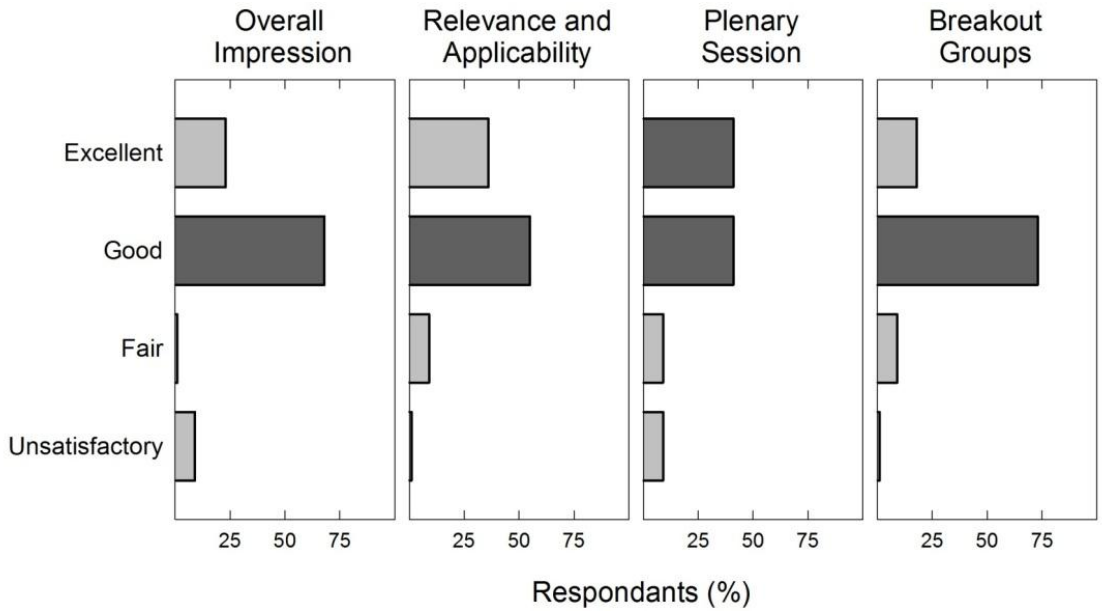

Figure 10: Participants assessment of the workshop. Results from an online, anonymous poll using Survey Monkey.

Two questions on the survey asked participants to rate their breakout session and to describe the strongest and weakest aspects of the workshop. Respondents provided meaningful feedback on the materials developed by the IEMM team in advance of the workshop, the structure of the workshop, and commented on the role of facilitators in diverse groups (Table 4).

The feedback was insightful and constructive. Interestingly, respondents were divided on almost every topic. For example, two respondents praised the materials distributed at the workshop as important starting points that were instrumental to the success of the group. Two other respondents argued that these same materials may have hampered the process in different ways. Similarly, some respondents praised the facilitators and others commented that their group needed more guidance from the facilitators. The diversity of feedback highlights that participants were a diverse group and brought different expertise and expectations to the workshop.

Topic	Pros	Cons
Draft Models and Reference Information Prior to Workshop	• I really liked the guidance provided prior to the break out sessions. It …gave people a starting point. • background materials and draft models were key to achieving what we did. otherwise I think the workshop would not have been a good use of time	• having sample conceptual models created may have put some participants off -- that is, we are considered the "experts" in the room, and it might have been more streamlined to first have the group take a crack at developing a conceptual model on our own • initial model … was inappropriate which resulted in significant waste of time
Collaboration and Learning in a Diverse Group	• My experience was very enlightening. I worked with people who were very knowledgeable in the field • I learned a lot and had fun doing it	• The experience of having a diverse group of well-intentioned, but uneven in experience/knowledge was challenging • I am not sure how we would do this in real-life, … models are being done by paid groups or else they are preserve-specific so we wouldn't actually be working with a mixed group like that.
Role of Facilitation	• The facilitators did an excellent job keeping the group on task and [on] … time	• would have benefitted from a little more "facilitation"
Workshop Format	• I was surprised that it was productive as it was • The compressed time frame and expected product limited discussions, but also helped to force us to focus on what we felt was most important to put into the models and hold out as uncertainties	• Our breakout group really didn't follow the process outlined in the initial presentation • too much to try to work through in the time available

Table 4: Comments from workshop participants. Participants were asked to rate their experience in the breakout group and to comment on the relevance of the workshop. Results from an online, anonymous poll using Survey Monkey.

The last question on the survey was “How interested are you in participating in future workshops hosted by IEMM?” Approximately 90% of respondents indicated they would participate in future workshops based on their impressions of the conceptual model workshop. This is an important gauge of their willingness to participate in this process despite the many demands on their time and energy.

TASK 4: INDEPENDENT SCIENTIFIC REVIEW

Independent scientific review serves an important role in the NCCP development and implementation process. Likewise, an independent review of IEMM's activities is an important component of the project to ensure our activities represented best available and robust science. We are convening an external review on May 16-18th to meet this objective. This external review will provide an independent assessment of the IEMM project, training activities (Task 1 and specific preserve-level work), review the goals and objective and conceptual model workshop products, and evaluate how IEMM has been supporting monitoring and management (Task 1 & 3).

The external review will be conducted by three independent scientists who represent a wide range of experience (academia, research institute, agency) who are highly qualified to review our work (see Appendix 7 for CVs). These scientists are supportive of, or engaged in, applied conservation science, have a strong publication record, and are engaged in academic:agency partnerships.

The work that the IEMM has conducted over the past year has led to a number of emerging themes related to how scientific support can improve monitoring and management activities at the preserve level, e.g. establishing robust monitoring protocols, analyzing monitoring data to inform management, facilitating the development of conceptual models, translating regional priorities to local actions. The review panel will provide an independent assessment of how well IEMM efforts have been able to or can meet these needs.

External Review Panel: Short Bios

Dr. Erica Fleishman is a researcher at the John Muir Institute of the Environment. She earned her BS and MS from Stanford University and her PhD from the University of Nevada, Reno. She has a wide range of expertise including biodiversity and conservation, climate change, invasive species, and land use planning. Dr. Fleishman's research integrates conservation science with management and policy, especially in the western US. She is also active in research on connectivity and its application to management of public and private lands and collaborates extensively with academic and agency researchers and practitioners. Dr. Fleishman is the editor in chief of the journal Conservation Biology.

Dr. Curtis Flather is a research wildlife biologist at the Rocky Mountain Research Station of the US Forest Service. He received his BS degree from the University of Vermont, and his MS and PhD from Colorado State University and holds affiliate faculty appointments within the Department of Fish, Wildlife, and Conservation Biology and the Graduate Degree Program in Ecology at Colorado State University. Dr. Flather is the Forest Service's Wildlife and Fish Specialist for Resource Assessments, and leads the agency's national assessments of resource status and trends. His research is focused on understanding wildlife population and community response to landscape pattern, in particular examining patterns of species endangerment, considering the effects of habitat fragmentation on species persistence, and evaluating biological indicators of sustainability. His research aims to extend the scientific basis for resource management in a manner that maintains the character (structure and process) of ecosystems while providing for human benefits derived from ecosystem services.

Dr. Sharon Collinge is an Associate Professor at the University of Colorado-Boulder in the Environmental Studies and the Ecology and Evolutionary Biology programs. She earned her BS in Biology at Kansas State University, an MS at University of Nebraska and a PhD in landscape ecology from Harvard University. Dr. Collinge was named a 2004 Aldo Leopold Leadership Fellow in recognition of her desire to communicate scientific issues beyond academic audiences. Dr. Collinge's research is based in grassland ecosystems of the American west and centers on how land use changes affect the survival and persistence of native plants and animals. Her work integrates ecological science with restoration of

endangered vernal pool species and ecosystems in California. She also has worked extensively with agencies and resource managers to study the combined effects of habitat alteration and wildlife community structure on the risk of disease outbreaks in the black-tailed prairie dog (*Cynomys ludovicianus*), a foundation species in western grasslands and a species of conservation concern.

TASK 5: TECHNICAL ASSISTANCE WITHIN THE MSCP

As part of the preserve-level work, IEMM has been involved in providing technical assistance for monitoring and management to a number of different projects and agencies within the MSCP. These beneficial collaborations have created opportunities to integrate the wide ranging expertise of planners, managers, and biologists at preserves with the scientific expertise of the IEMM team. A few examples of recent collaborations are described below.

California Least Tern (CLTE) habitat restoration at Mission Bay Park:

IEMM worked with the San Diego Audubon Society to develop a restoration plan and adaptive monitoring program for CLTE nesting areas at Mission Bay Park. The IEMM developed the framework to restore native coastal dune plants in these areas using four treatments (adding sand, adding native seed, adding both sand and seed, and hand-weeding, Figure 11). IEMM also developed a vegetation monitoring program to capture changes in percent vegetation cover, vegetation height, and species composition within each treatment. The same monitoring protocol will also be used to evaluate the effects of plant cover and structure on nesting occurrence and fledgling production at Mariner's Point. Initial baseline monitoring of the restoration treatment and control plots was conducted by students enrolled in Plant Ecology at SDSU, both to train the staff that will be working at the preserve and to ensure data quality.

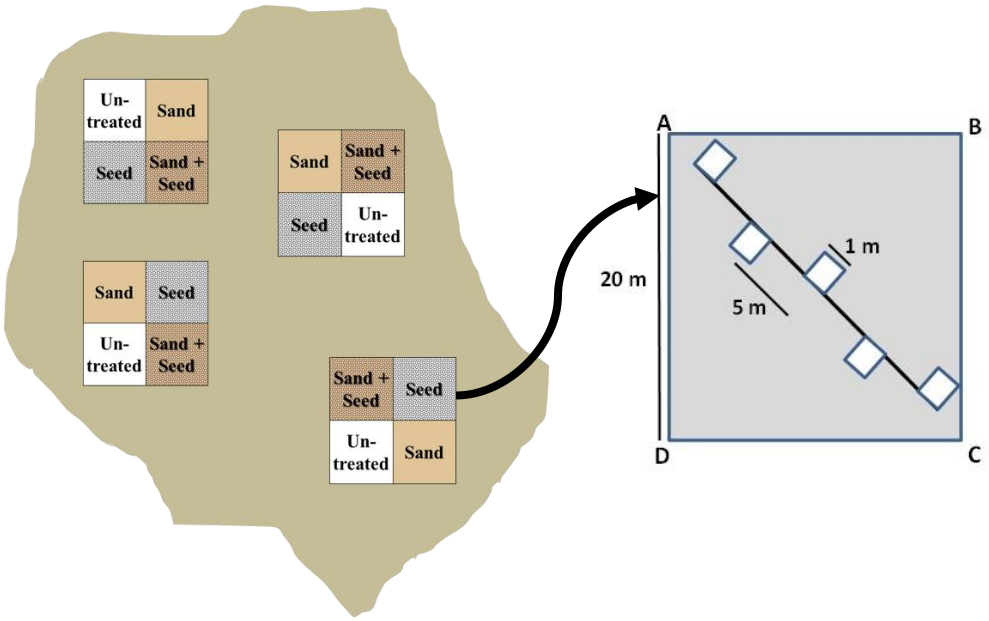

Figure 11. (Left) Experimental design: Four blocks of a 2x2 factorial experiment.
(Right) Transect and quadrat configuration for vegetation monitoring.

Staff from the IEMM, students from the plant ecology class at SDSU, and volunteers from the Audubon society completed initial vegetation monitoring in April 2012. Preliminary analyses of the data demonstrate that the method captures both the composition and structure of the habitat. Mariner's point is dominated by the native species including Nuttal's lotus (*Acmispon prostrates*) (Figure 12, top). The vegetation is patch and low, with ~90% of the points are either unvegetated or less than 10cm tall. Stony Point and North Fiesta have more open areas, lower plant cover and are dominated by non-natives (Figure 12, bottom).

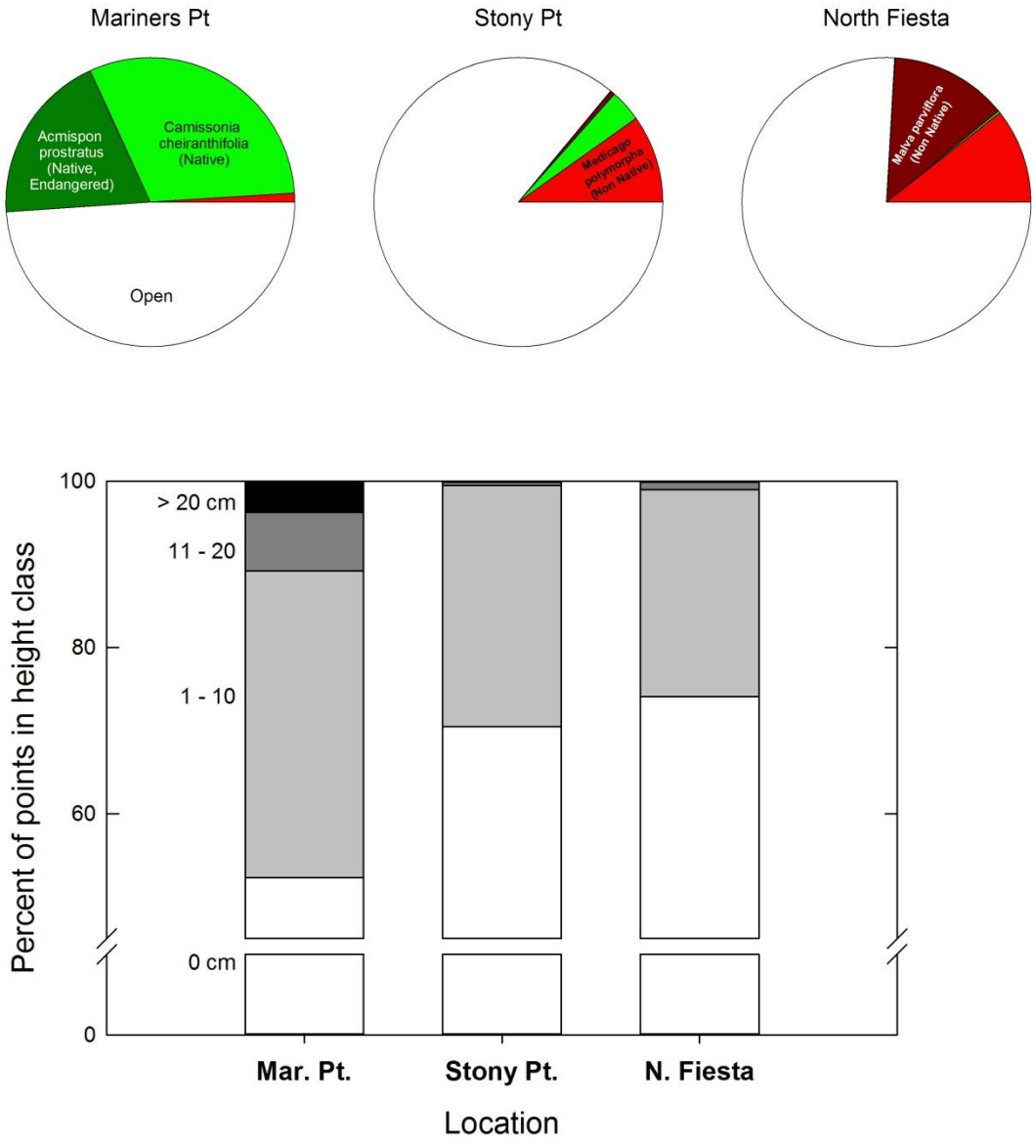

Figure 12. (Top) Relative cover of common species.
(Bottom) Vertical structure (height of vegetation)

We have also begun a comprehensive statistical analysis of the productivity data from Mission Bay (Figure 13). The relationship between colony size and productivity (a per capita measure of reproduction) is not statistically significant, though we cannot rule out a modest relationship. Instead, the largest signal is the tremendous drop in productivity observed since 2004 (Table 5 and red points in Figure 13). Productivity averaged approximately 0.51 (SE ± 0.08) before 2004 and dropped to 0.11 (SE ± 0.04) after 2004. The IEMM is continuing this work and will focus on analyzing productivity data state-wide to consider the potential link between colony size, productivity and other variables.

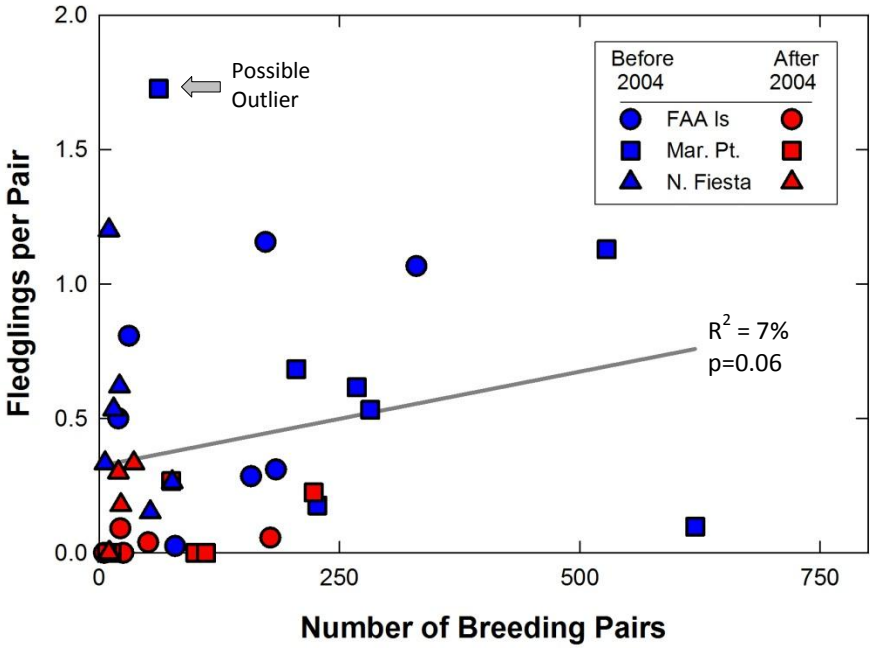

Figure 13. Nest productivity (fledglings per pair) as a function of the number of breeding pairs. Symbols differentiate the three main sites in Mission Bay. Red symbols are data collected after 2004.

Table 5: Analysis of Variance (ANOVA) table for nest productivity data.

ANOVA R^2 = 25%					
Source	SSQ	DF	MSQ	F	P
Time Period	1.370	1	1.370	9.01	0.005
Number of Pairs	0.021	1	0.021	0.14	0.712
Interaction	0.009	1	0.009	0.06	0.809
Error	5.308	35	0.152		

Analysis of factors impacting Burrowing Owl (BUOW) presence at artificial burrows:

IEMM worked with the California Department of Fish and Game to analyze data collected on habitat variables around artificial BUOW burrows. Factors evaluated included measures of vegetation structure (vegetation height at the artificial burrow and 15m away), vegetation composition (common species, dominance by non-native grasses, presence of cholla), and the presence of other animal species like ground squirrels and wood rats.

Results indicated two primary drivers of burrowing owl presence: 1) presence of grass as the dominant plant cover reduced the probability of BUOW presence (and 2) vegetation height both at the burrow and at 15m from the burrow (Figure 14). We plan to re-visit this analysis with California Department of Fish and Game as more years of data become available.

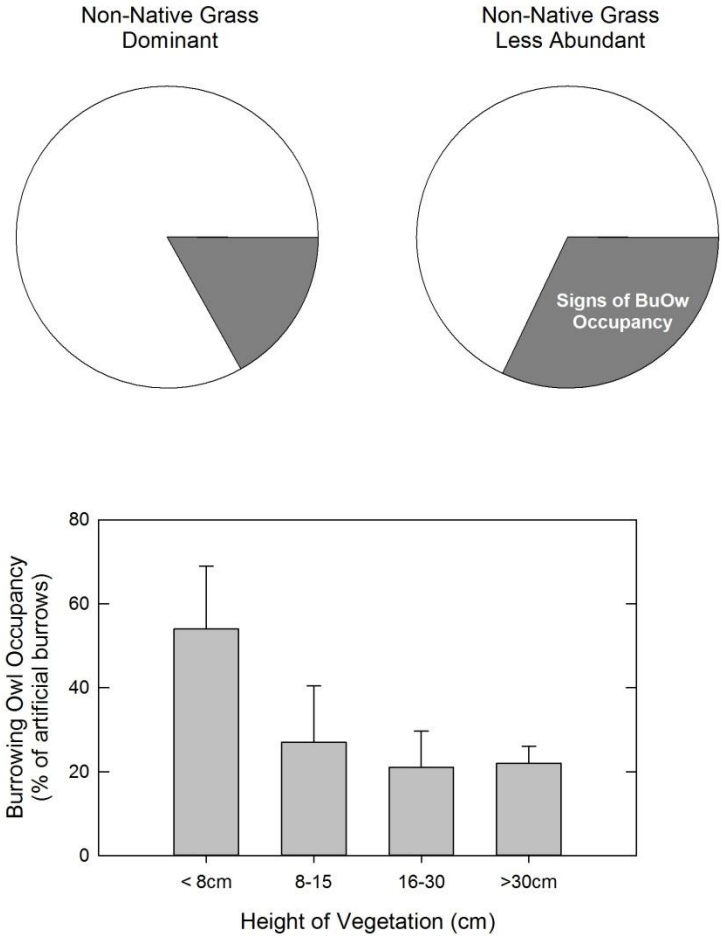

Figure 14. Factors related to Burrowing Owl occupancy at artificial burrows. Data from Nancy Frost, DFG.

Monitoring support for cattle management of Burrowing Owl habitat

IEMM has provided monitoring recommendations in support of a proposed project at CA DFG's Rancho Jamul Ecological Reserve to use cattle to manage vegetation for burrowing owl habitat. In support of this effort, IEMM has made recommendations for establishing long-term monitoring plots and for implementing a modified range-sampling scheme to address adaptive management decision making for vegetation management with cattle. IEMM also consulted with USDA-NRCS and CBI on monitoring approaches and ways to coordinate monitoring efforts between this project and additional grassland management projects in San Diego County.

Figure 15. Non-native grasses in burrowing owl management area, Rancho Jamul Ecological Reserve.

Design and analysis of experiments on invasive grass control at Crestridge

IEMM collaborated with CBI to conduct statistical analysis of data from ongoing CBI experiments testing the efficacy of herbicide and mechanical control measures on the invasive grass, *Brachypodium distachyon*. This grass species has heavily invaded (Figure 16) clay and gabbro soils which support rare endemic plant species such as San Diego thornmint (*Acanthomintha ilicifolia*), thread-leaved brodiaea (*Brodiaea filifolia*), and Dehesa beargrass (*Nolina interrata*).

Figure 16. The rare Dehesa beargrass in a grassland dominated by the non-native grass *Brachypodium distachyon.* Photo taken at South Crest

Statistical analysis of data from the first year of this ongoing experiment show that both mechanical and chemical control reduce the cover of non-natives, but that chemical control is more effective ($F_{2,12}$ = 50.88, p<0.001). The removal of thatch did not significantly improve the efficacy of either treatment ($F_{2,12}$ = 2.60, p=0.115) though we should not exclude the possibility of a differential response with this limited dataset. This initial analysis helped in the design of additional experiments being implemented in 2012-2013 on *Brachypodium* control at the South Crest reserve.

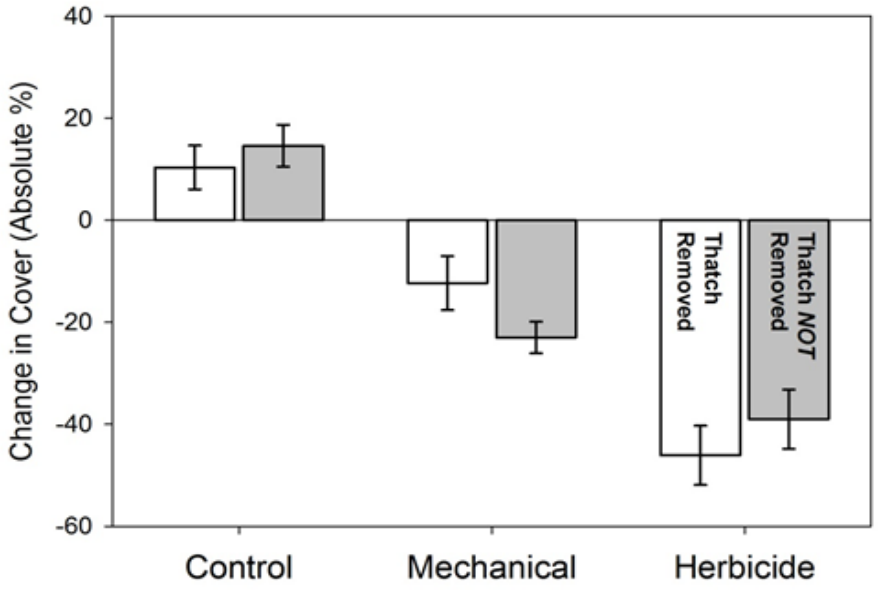

Figure 17. Change in cover in response to mechanical or chemical (herbicide) treatment. Thatch removal was not statistically significant but should not be ruled out.

TASK 6: FINAL REPORT

Adaptive management is driven by effective and efficient monitoring and management, supported by an iterative process by which monitoring data can be used to inform and guide management. Improving the adaptive management process has been the focus of work at the local, regional and national level and continues to challenge resource and land-use management and planning. The work conducted by IEMM serves to strengthen the adaptive management process in the MSCP by supporting focused preserve-level work (decentralized, site-specific activities) as well as engaging in more community-focused training exercises (centralized activities) for a wide range of stakeholders. This report documents all the activities the IEMM has engaged in to improve how adaptive management is implemented in the MSCP.

The preserve-specific decentralized activities, as discussed in Task 1 & 5, were the main focus of the IEMM efforts. The document review and synthesis described in Task 1 served as an excellent starting point for the project. Guided by an ad hoc steering committee, the IEMM compiled all relevant management and monitoring documents for the seven focal preserves/preserve complexes, which itself was an important deliverable as it had not been done before. This document compilation provided the IEMM research team with an excellent understanding of the types of monitoring and management activities that had been conducted to date and served as an excellent platform to establish a strong collaborative working relationship with preserve rangers and managers. For two preserves (Otay Ranch Preserve and Mission Trails Regional Park), this document compilation and review led to more direct review and improvement of management documents in development.

As part of the preserve-level work, IEMM has also been involved in providing technical assistance for monitoring and management on a number of different projects, as well as providing training and capacity building for preserve staff. These productive partnerships have directly addressed unanswered management questions and created opportunities to integrate the wide ranging expertise of planners, managers, and biologists at preserves with the scientific expertise of the IEMM team. The project on California Least Tern (CLTE) habitat restoration was instrumental in supporting SANDAG-funded land management activities in Mission Bay. The experimental design and monitoring program that IEMM devised and implemented will allow the preserve-level managers at Mission Bay to evaluate the link between vegetation conditions and CLTE nesting and reproductive activity. The IEMM will be continuing to conduct analyses of existing CLTE data with agency partners. IEMM efforts were also instrumental in analyzing data to help inform management of invasive grass control at Crestridge and of vegetation characteristics that might influence burrowing owls presence at artificial burrows. These activities highlight the important contribution of the IEMM, namely by providing support to help preserves establish scientifically robust monitoring programs, and analyzing existing monitoring data. Both of these are critical steps in the adaptive management process and are needs the IEMM directly fills.

In addition to the preserve-level work, the IEMM convened a series of two training workshops for the wider management and monitoring community. The workshops were developed as an integrated series to review and explore two fundamental steps of the adaptive management process. The first workshop explored the importance and utility of robust goals and objectives to monitoring and management, and explored the challenges in developing goals and objectives. Even with the excellent technical manuals available to managers, developing robust goals and objectives continues to present some veritable challenges in hands-on application. The workshop focused on goals and objectives at the preserve level, while recognizing the importance of placing local goals and objectives in the broader regional context. The second workshop continued the discussion initiated at the Goals and Objectives workshop and focused on the process of conceptual model construction, evaluation and review. This

process helps to formalize assumptions of how stakeholders believe a system works, provides the community with an opportunity to document the source of that knowledge (e.g. expert opinion, published research) , and helps direct future management, monitoring and research efforts by identifying critical sources of uncertainty.

For both workshops, we solicited extensive feedback before and after each workshop. Soliciting feedback from participants prior to the workshops afforded us with information that we used to maximize the impact and relevance of the workshop to the participants. Post-workshop feedback was similarly important to shape and inform future workshops, and to evaluate the success of different workshop elements. Anonymous feedback from both workshops was overwhelming positive, with participants providing constructive criticisms as well as support for the training opportunity. The level and the transparency of reviews we conducted around IEMM activities are important to ensure workshops and similar meetings are serving the needs of the management community and should be a requirement for all organizations engaging in similar activities.

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APPENDICES

Task	Appendix	Description
Task 1	Appendix 1:	Log of preserve activities
	Appendix 2:	Annotated list of reviewed documents
	Appendix 3	Report from the Goals and Objectives workshop
	Appendix 4	Appendices from the Goals and Objectives workshop report
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	Appendix 6	Presentation on Conceptual Models
Task 4	Appendix 7	CV's for the three external science reviewers

APPENDIX 1 – LOG OF PRESERVE ACTIVITIES

AGENCY	DATE	ATTENDEES	BRIEF SYNOPSIS
City of San Diego DPR City of San Diego Public Utilities	10.3.11	Betsy Miller, Josh Garcia, Niki McGinnis, Doug Deutschman, Becca Lewison, Pat McIntyre, Erin Marnocha, Catherine Tredick	IEMM provided overview of project objectives. City discussed needs and issues at San Vicente and Otay Lakes Cornerstone Lands, and Los Penasquitos, including data analysis, prioritization of monitoring activities, refining mgmt directives, training staff on the ground to monitor integrity of cornerstone lands.
City of San Diego DPR	10.18.11	Gina Washington, Betsy Miller, Josh Garcia, Becca Lewison, Pat McIntyre, Erin Marnocha, Catherine Tredick	Site visit to Los Penasquitos and Del Mar Mesa. Examined and discussed concerns and issues on the ground, including erosion (urban runoff), trail/access issues, rare plant and active restoration locations.
City of San Diego Public Utilities	11.3.11	Niki McGinnis, Spring Strahm, Pat McIntyre, Erin Marnocha, Catherine Tredick	Site visit to Otay Lakes and San Vicente Cornerstone Lands. Examined and discussed concerns and issues on the ground, including access issues (ORVs), desire for their few on-the-ground folks to be trained to rapidly assess habitat condition in given areas.
City of Carlsbad CNLM	10.12.11	Mike Grim, Markus Spiegelberg, Doug Deutschman, Becca Lewison, Pat McIntyre, Erin Marnocha, Catherine Tredick	IEMM provided overview of project objectives. MS provided background on CNLM and discussed their needs and issues in Carlsbad, including rare plant monitoring, connectivity, data analysis, and prioritization of management activities.

AGENCY	DATE	ATTENDEES	BRIEF SYNOPSIS
CNLM	11.14.11	Markus Spiegelberg, Jesse Vinje, Patrick McConnell, Pat McIntyre, Catherine Tredick, Erin Marnocha	Site visit to CNLM managed lands in Carlsbad. Examined and discussed concerns and issues on the ground, including management of small fragments and their regional context, analysis of rare plant experiments, access issues, invasive control, urban runoff, monitoring design.
City of Chula Vista RECON	10.19.11	Marisa Lundstedt, Glen Laube, Mark Dodero, Doug Deutschman, Becca Lewison, Pat McIntyre, Erin Marnocha	IEMM provided overview of project objectives. City discussed their needs and issues at Otay Ranch Preserve, including refinement of their RMP and work plans, data analysis, and developing measures of ecosystem integrity.
City of Chula Vista RECON	12.15.11	Marisa Lundstedt, Glen Laube, Mark Dodero, Becca Lewison, Erin Marnocha, Catherine Tredick	Site visit to Otay Ranch. RECON discussed problems with invasives along riparian areas, difficulty monitoring FUDS area, issues with Border Patrol creating roads and disturbing habitat.
City of Chula Vista RECON	2.8.12	Glen Laube, Mark Dodero, Becca Lewison, Erin Marnocha, Pat McIntyre, Catherine Tredick	Met to discuss how a program for monitoring the impacts of climate change on City of Chula Vista lands could be developed. Phenology, photo-points, and other measures were mentioned as possible targets for the monitoring program.
City of Poway	10.26.11	Jim Lyon, Richard Whipple, Ron Rempel, Yvonne Moore, Doug Deutschman, Becca Lewison, Pat McIntyre, Erin Marnocha, Catherine Tredick	IEMM provided overview of project objectives. City does not have an active management program, but expressed interest in working with IEMM and neighboring preserves to protect resources and deal with access and other mgmt. issues.

AGENCY	DATE	ATTENDEES	BRIEF SYNOPSIS
CA DFG	11.4.11	Terri Stewart, Karen Miner, Dave Lawhead, Nancy Frost, Tracie Nelson, Warren Wong, Jason Price, Doug Deutschman, Becca Lewison	IEMM provided overview of project objectives. DFG discussed needs and issues at San Vicente OSP and Otay Mountain and expressed interest in working with IEMM in other areas as well.
CA DFG	12.7.11 1.24.12	Warren Wong, Jason Price, Tracie Nelson, Erin Marnocha, Pat McIntyre, Catherine Tredick	Site visit to San Vicente Highlands and Batiquitos Lagoon, with follow-up on 1.24.12 to Rancho Jamul. Discussed problems with invasive management, ideas for grant preparation support for targeted projects within reserves, and science support for species management.
CA DFG	3.15.12 3.29.12	Tracie Nelson, Patrick McIntyre	IEMM provided recommendations on monitoring methods in support of a proposed project to use cattle grazing to manage for burrowing owl by reducing the density of vegetation within a target management area.
Endangered Habitats League Conservation Biology Institute	11.9.11	Michael Beck, Doug Deutschman, Becca Lewison, Pat McIntyre, Erin Marnocha, Catherine Tredick	IEMM provided overview of project objectives. EHL discussed needs in terms of additional scientific support for CBI monitoring and restoration projects, scientific analysis of connectivity/corridors, annual report content, and assessment of environmental education activities, and other management issues including Hermes copper and acquisition of additional properties.

AGENCY	DATE	ATTENDEES	BRIEF SYNOPSIS
Conservation Biology Institute	11.30.11*	Patricia Gordon-Reedy, Pat McIntyre, Erin Marnocha, Catherine Tredick	Site visit to Cestridge and South Crest to discuss invasive species control and rare plant management. Provided freed back on design of an experiment targeting control of the invasive grass *Brachypodium distachyon.*
Conservation Biology Institute CNLM	12.7.11	Patricia Gordon-Reedy, Patrick McConnell, Pat McIntyre, Doug Deutschman, Spring Straham	Met to provide scientific support on design and analysis of separate experiments CBI and CNLM on control of the invasive grass *Brachypodium distachyon* and exchange ideas across these experiments.
BLM	11.16.11*	Joyce Schlachter, Doug Deutschman, Pat McIntyre, Erin Marnocha, Catherine Tredick	IEMM provided overview of project objectives. BLM indicated need for better coordination and communication with other regional research efforts (e.g., Quino, cactus wren, etc.) and with researchers doing work on BLM lands.
BLM	12.5.11	Joyce Schlachter, Becca Lewison, Pat McIntyre, Erin Marnocha, Catherine Tredick	Site visit to Otay Mountain. BLM discussed needs in terms of coordination and improved communication with other agencies and researchers conducting work on BLM lands. Border Patrol creates numerous roads out on Otay Mtn and subsequently destroys habitat.

AGENCY	DATE	ATTENDEES	BRIEF SYNOPSIS
City of San Diego DPR	2.3.12	Betsy Miller, Josh Garcia, Mike Nieto, Doug Deutschman, Becca Lewison, Pat McIntyre, Erin Marnocha, Catherine Tredick	Met with City of SD and RECON biologist (Mike Nieto) regarding the draft management plan for Mission Trails Regional Park. IEMM discussed the need for clear goals and objectives throughout the document and a more streamlined and integrated discussion of management tasks, perhaps organized by guilds or other groupings. The need for a more regional context also was discussed, along with a "punchlist" to assist land managers in prioritizing and budgeting management tasks.
San Diego Audubon Society City of San Diego DPR	1.5.12	Roxy Carter, Chris Redfern, Lori Gerbac, Stephanie Ferris, Betsy Miller, Ron Swaisgood, Joelle Fournier, Mike Kelly, Becca Lewison, Catherine Tredick	Initial site visit to Mission Bay to observe sites and begin thinking about restoration plan and monitoring protocol.
San Diego Audubon Society	2.13.12	Chris Redfern, Roxy Carter, Becca Lewison, Catherine Tredick, Tom Zink	Conference call with SD Audubon and SDSU SERG to determine best practices for removing iceplant and restoring native coastal dune plants at South Shores.
San Diego Audubon Society	4.5.12 4.12.12	Roxy Carter, Doug Deutschman, Catherine Tredick, others	SDSU Plant Ecology class spent 2 afternoons out at Mission Bay collecting initial vegetation monitoring data at CLTE nesting sites (Mariner's Point, Stony Point, and North Fiesta Island)

APPENDIX 2 –MANAGEMENT DOCUMENTS COMPILATION AND SYNTHESIS

Potential Preserve Name (Owner/Mgr)	Relevant documents In Hand	Documents we have seen referenced but do not have
Crestridge (DFG/EHL)	• Final Draft HMMP 2009 • County MSCP Monitoring Report 1998-2007	
Carlsbad complex (City Carlsbad/ CNLM)	• PMP 2008 (Carlsbad) • HMP 2004 (Carlsbad) • AR 2009 (Carlsbad) • AR 2010 (Carlsbad) • PMPs and 2010 AR for CNLM managed lands • PMP and 2010 AR for Emerald Pt • 2010 AR for Buena Vista ER (CNLM)	• Batiquitos 2003 Draft MP • Buena Vista MP
Mission Bay (City SD)	• NRMP 1990 • City SD MSCP ARs 1998-2004 • Nutall's lotus reports 2000-2009	
Black Mountain (City SD)	• Draft NRMP 2010 • City SD MSCP ARs 1998-2004 • Rare plant reports 2001-2009	
Mission Trails (City SD)	• Master Plan 1985 • City SD MSCP ARs 1998-2004 • rare plant reports 2001-2009	• Draft of updated Plan

PMP = Preserve Management Plan
RMP = Resource Management Plan
NRMP= Natural Resource Management Plan
HMP = Habitat Management Plan
HMMP = Habitat Monitoring and Management Plan
FMP= Framework Management Plan
AR= Annual Report
ASMD = Area-Specific Management Directive

Potential Preserve Name (Owner/Mgr)	Relevant documents In Hand	Documents we have seen referenced but do not have
San Vicente (DFG/County) El Capitan (BLM/County)	• ASMDs 2007 (San Vicente) • RMP 2009 (El Capitan) • Baseline bio survey 2008 (El Capitan) • County MSCP Monitoring Report 1998-2007 • County MSCP ARs 1998-2010	• San Vicente Biological Resource Report (Merkel 2002)
Sloan Cyn (DFG) *This property was referenced in Madden-Smith 2005 ARTO_WPT report as important habitat for these species.*	**NONE**	
Otay Lake/Daley Cyn (City SD)	• 2005 BUOW MP • 2005 & 2006 BLM Quino Reports • City SD MSCP ARs 1998-2004 • rare plant reports 2001-2009	
Del Dios (County) Lake Hodges (City SD) 4S Ranch (private/HOAs)	• RMP 2011 (Del Dios) • Baseline Biodiversity Survey 2011 (Del Dios & others) • Biological Diversity Baseline Report 2009 (Del Dios) • Del Dios Vegetation Management Plan 2011 • HMP 2003 (Lake Hodges) • City SD MSCP ARs 1998-2004 (Lake Hodges) • 2008 habitat monitoring report for 4S (Dudek) • County MSCP Monitoring Report 1998-2007 • County MSCP ARs 1998-2010	• HMP 1999 for 4S Ranch

PMP = Preserve Management Plan
RMP = Resource Management Plan
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HMP = Habitat Management Plan
HMMP = Habitat Monitoring and Management Plan
FMP= Framework Management Plan
AR= Annual Report
ASMD = Area-Specific Management Directive

Potential Preserve Name (Owner/Mgr)	Relevant documents In Hand	Documents we have seen referenced but do not have
Escondido Creek (County)	• RMP 2011 (County) • Veg MP 2011 (County) • Baseline Biodiversity Survey 2011 (Dudek) • Restoration Action Strategy 2005 (EC Conservancy - not sure if this is relevant)	
Daley Ranch (City Escondido)	• Master Plan 1998	• Biological Resources Assessment 1995
Los Penasquitos Lagoon (City SD)	• Master Plan 1998 (no mention of MSCP) • Watershed MP 2005 (not sure if this is relevant) • Rare plant reports 2001-2009	
Ramona Grasslands (County)	• FMP 2004 • ASMDs 2007 • Baseline bio survey 2007	
Sweetwater Res. (SW Authority)	**NONE**	

PMP = Preserve Management Plan
RMP = Resource Management Plan
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HMP = Habitat Management Plan
HMMP = Habitat Monitoring and Management Plan
FMP= Framework Management Plan
AR= Annual Report
ASMD = Area-Specific Management Directive

Regional/ multi-preserve surveys (candidate preserves that are included are listed below):

- 2002-2003 arroyo toad and western pond turtle county wide (multi-county)
- 2006 & 2010 Belding's savannah sparrow survey – Mission Bay, Los Penasquitos, Carlsbad Lagoons
- 2008 & 2009 Light-footed clapper rail survey - Mission Bay, Los Penasquitos, Carlsbad Lagoons
- 2002 BUOW survey report – Otay Lakes, Ramona Grasslands
- 2001 CAGN survey – Lake Hodges, Black Mtn, Los Penasquitos, Mission Trails
- 2006 CAGN region-wide occupancy study
- 1999 Quino survey – Otay Lakes, Mission Trails, San Vicente
- 2000 Quino survey – Otay Lakes, Mission Trails, Lake Hodges
- 2003 Quino survey – Otay Lakes and Mission Trails
- 2003 countywide raptor survey (most locations above)
- 2003 vernal pool inventory – Mission Trails and Otay Lakes
- County MSCP monitoring overview 1998-2007 – Crestridge, San Vicente, 4S Ranch, Del Dios
- 1993-2009 CA least tern monitoring reports – Mission Bay
- various least bell's vireo reports and papers
- various SW willow flycatcher reports and papers
- Hermes copper surveys 2010 – Mission Trails, Black Mountain, Crestridge, Sycuan Peak

APPENDIX 3 – REPORT FROM THE GOALS AND OBJECTIVES WORKSHOP

Developing and Refining Goals & Objectives for Monitoring and Management:

Building and implementing an integrated framework for monitoring and management in San Diego County

Proceedings from a workshop held
Wednesday, November 2nd, 2011, Mission Trails Regional Park

Prepared By:
RL Lewison, DH Deutschman, E Marnocha, C Tredick, and P McIntyre
Institute for Ecological Monitoring and Management

San Diego State University

Introduction

On November, 2, 2011, The Institute for Ecological Monitoring and Management (IEMM) hosted a day-long workshop that explored the importance and utility of robust goals and objectives to monitoring and management. The meeting's 55 participants represented a diverse array of backgrounds and experience, including land/preserve managers, resource managers, biologists, planners, rangers, and regulatory agency staff. The purpose of the workshop was to provide an opportunity for the local land management community to come together and discuss the importance and difficulties of constructing effective goals and objectives in the context of monitoring and management. In particular, the workshop explored the challenges in developing goals and objectives that follow the specifications outlined in existing templates and guidelines on writing management plans (Paveglio and Taylor 2010, Adamcik et al 2004). Even with these and other excellent technical manuals, developing robust goals and objectives continues to present some veritable challenges in hands-on application. The workshop focused on goals and objectives at the preserve level, while recognizing the importance of placing local goals and objectives in the broader regional context, concurrent work led by the San Diego Monitoring and Management Program (SDMMP) program.

In the first half of the workshop, the workshop participants met in plenary to review working definitions and criteria for goals and objectives. As a group, we also reviewed some current examples of goals and objectives for species and natural communities of conservation concern. In addition, we considered the importance of connecting preserve-level goals and objectives within a regional context. Finally, land managers from three different organizations shared their perspectives and personal experiences with writing effective goals and objectives.

During the second half of the workshop, participants were asked to confront the challenges in developing goals and objectives by working collaboratively in small, focused working groups writing goals and objectives that met the SMART criteria. SMART is an acronym used by the US Fish and Wildlife Service (FWS**;** Adamcik et al 2004) that represents the key features of a robust objective, one that is **s**pecific, **m**easurable, **a**chievable, **r**esults-oriented and **t**ime-fixed. In small breakout groups, workshop participants worked to write SMART goals and objectives for five current management issues: i) rare and endemic species, ii) wide-ranging species and connectivity, iii) invasive species, iv) stewardship, education and outreach, and v) ecosystems and natural communities. . The expert knowledge, scientific experience and expertise are captured in the group products and narratives in the breakout summaries below.

Background

Goals and objectives serve as key foundation for effective monitoring and management. Goals are broad, concise visionary statements that set overall direction for monitoring and management. In contrast, objectives are concrete and measurable statements that detail how a specific goal can be attained. Schroeder (2006) provides an excellent definition of an objective as a "*concise statement of what we want to achieve, how much we want to achieve, when and where we want to achieve it, and who is responsible for the work*". Often multiple objectives are needed to meet a single goal. Based on objectives, managers can then determine what monitoring and management strategies (sometimes called implementation tasks) are needed to meet specific objectives and the overall goal.

Recent reviews of published and established goals and objectives provide insight on the fundamental challenges in developing robust goals and objectives (Tear et al 2005, Schroeder 2006, 2009). One challenge relates to the confusion in the definition of terms, e.g. how is a goal different than an objective. The other challenges relate to the complexity of capturing best-available science (which may be influenced by limited resources, time and/or expertise), a desire to maintain flexibility on the part of managers, and the challenges with concretely quantifying change either in species or natural communities, or both. For all these reasons, lack of robust goals and well-articulated objectives continues to limit effective monitoring and management.

Perspectives from Land Managers

To capitalize on the extensive expertise and knowledge of stakeholders in San Diego County, we invited three local land managers to give their perspectives on the importance of goals and objectives, challenges and difficulties of developing and implementing goals and objectives, and general or personal experience developing and implementing goals and objectives. The following is a brief summary of their thoughts.

Betsy Miller: City of San Diego Parks and Recreation

Betsy shared with the group her thoughts on the importance of working collaboratively across agencies, areas of expertise, and preserves. She stressed the importance of using collective expertise to develop consensus-based performance measures and expressed support for opportunities for land managers, planners, and rangers to get together to share knowledge and experience. She also acknowledged the need for a stronger link between regional and preserve scales within the MSCP.

Markus Spiegelberg: Center for Natural Lands Management

Markus shared his perspective of managing a network of small, fragmented preserves in a highly urbanized environment within the MHCP. This presents unique challenges that generally are not addressed in many of the MSCP documents. Unlike larger, connected preserves, monitoring and management on smaller preserves is challenged by lack of coordination, lack of data, increased edge effects, and small sample sizes. These factors may also lead to specific and/or highly localized stressors for small preserves or small preserve networks. In most cases, fragmented preserves must rely on neighboring lands and land owners to get meaningful work done. Markus also suggested that most managers are working with outdated plans that need to be re-interpreted or updated in order to be effectively implemented on the ground. He acknowledged the difficulty of translating large-scale goals and objectives into measurable and meaningful objectives at a smaller scale.

Michael Beck: Endangered Habitats League/Conservancy

Michael shared his perspective that there is a large gap between prospective land-use planning and current monitoring and management in the MSCP. He acknowledged that the monitoring and management feedback loop must advise land use, but there currently is a disconnect between land-use planners and conservation. For example, the characterization of functional linkages in the MSCP plan is

inconsistent with some of the recent planning decisions. Furthermore, he discussed the tension between a species-by-species approach to monitoring and management and a whole-system approach. At the subregional (preserve) level, funding obligations of the various subarea plans impact whether anything can really get done, particularly more than just species-by-species management obligations.

Michael also acknowledged that meeting requirements of the MSCP is difficult for managers, and stated that EHL/EHC is constantly expanding the scope of their activities in order to meet them. Currently, EHL doesn't really have a single on-the-ground manager; rather, it's a composite of different people, groups, and agencies (e.g., CBI, Earth Discovery Institute, volunteers, and other contractors). He added that it is important to link various land managers strategically within management units. For example, the Harbison Canyon/Crestridge/Lakeside Archipelago includes CDFG, USFWS, County of San Diego, Caltrans, and EHC as land managers. Linking land managers would include not only increased communication among agencies, but coordinated implementation actions as well, including wildlife tracking, invasive mapping and control, and restoration strategies.

Michael stressed the importance of environmental education to a successful preserve management program now and into the future as well. Between 3,000-4,000 school-age children visit Crestridge every year, along with teachers and other educators, to learn the importance of stewardship and conservation. These student groups and other volunteers do a lot of the hands-on management at Crestridge as well, including invasive species removal and restoration planting. This collaborative effort is largely grant funded. Most funding necessarily goes to basic stewardship: maintenance, security, monitoring usage and access issues, removing invasives, etc., leaving little leftover for biological monitoring or research.

IEMM presentation

In preparation for the breakout groups, the IEMM (R. Lewison and D. Deutschman) presented an overview of the importance of goals and objectives within the context of monitoring and management, the challenges faced when developing goals and objectives, and the utility and benefits of using SMART criteria. We also reviewed three relevant examples of species or natural communities that are actively managed in the San Diego region but pose different challenges in developing effective goals and objectives. We explored potential goals and objectives for each of these systems and assessed how well the objectives meet the SMART criteria.

SDMMP Presentation

Ron Rempel, Program Administrator for the San Diego Management and Monitoring Program, provided an overview of the Management Strategic Plan (MSP) being developed for the EMP Working Group. The MSP will provide guidance for implementation of regional level management in western San Diego County and will define goals and objectives for managing species and habitats at the regional level. The MSP also will guide the allocation of regional funding. During the presentation, reserve managers were encouraged to take into account the regional goals and objectives when developing specific goals and objectives for species and habitats that occur on their individual preserves.

Breakout Group Exercise

A primary focus of the workshop was to facilitate the exchange of ideas in smaller breakout groups. These groups were tasked with developing specific and concrete goals and objectives for species, communities, threats, and stressors that are relevant to San Diego County (group topics are listed below). Although the group exercise was designed to provide direct experience with goal and objective development, the ultimate purpose of the exercise was to give participants meaningful experience with the *process* of developing effective goals and objectives, rather than developing exemplar objectives that would be directly adopted by managers. Topics were intended to be narrow enough to provide the opportunity for each group to create concrete goals and objectives, but broad enough to be relevant to managers across preserves. Topics were chosen to represent a range of management issues, from monitoring of rare species to managing recreational use and access. The final breakout topics reflect feedback from the pre-workshop survey sent to invitees. Each group was asked to consider how their developed goals and objectives would need to be changed or modified when applied to different types of preserves (e.g., small vs. large preserve, isolated preserve vs. a preserve that exists as part of a network or preserve complex.). The group topics were:

- Rare and endemic species
- Wide-ranging species and connectivity
- Invasive species
- Stewardship management, education and outreach
- Ecosystems and Natural Communities

Participants self-selected into groups by signing up for their first and second choice of topics. IEMM staff then assigned individuals to a group topic in order to assure fairly even group sizes and to ensure diversity of participants (e.g. rangers, biologists, regulators) within each group. Within the broad group topic, participants selected a narrower focal topic to develop specific goals and objectives. A list of management topics and focal species that were recommended by the EMP working group for SANDAG funding priorities for 2012 were provided to the groups in order to facilitate topic choices that might reflect relevant management funding priorities

IEMM staff acted as facilitators where needed, but the process was largely driven by group participants. Members of the group were asked to document the goals and objectives formulated and to provide a narrative which documented the assumptions and expert knowledge used in the development process. At the end of the workshop, each group gave a 5-10 minute presentation to all of the workshop participants, stating the goals and objectives their group developed as well as the points of discussion that were part of that development.

IEMM staff then compiled and edited the presentations from each working group. The presentations were put into a common presentation style and narrative. A draft of this workshop report was then sent to participants for their input. This assures that the report accurately reflects the group's ideas. As a result, this report reflects the views of a diverse cross-section of stakeholders, land managers, and scientists.

Breakout Group 1: Rare and Endemic Species

Participants:

Tim Dillingham
Biologist
California Department of Fish and Game

Michael Galloway
Biologist
CalTrans

Rosanne Humphrey
Biologist
ESA Biological Resources

John Martin
Refuge Biologist
U.S. Fish and Wildlife Service

Patrick McIntyre
Postdoctoral Fellow
San Diego State, IEMM

Betsy Miller
MSCP Biologist
City of San Diego, Parks and Recreation

Zach Principe
Biologist
The Nature Conservancy

Ron Rempel
Director
San Diego Management and Monitoring Program

Linnea Spears-Lebrun
Biologist
AECOM

Jessica Vinje
Preserve Manager
Center for Natural Lands Management

Susan Wynn
Biologist
U.S. Fish and Wildlife Service

Background: Rare and endemic species was chosen as a break-out group topic because these restricted species are a key focus of reserve management plans and the MSCP, and management of these species is often centered at the preserve level. Individual reserves may have one of only a handful of known populations, or in some cases the only known population of a species. While assessment of the regional importance of the population on a reserve is important, local rather than regional processes and management actions are relatively more important for these taxa.

Chosen topic: San Diego thorn-mint (SDTM), an annual plant generally restricted to clay soils and known only from San Diego county and northern Baja, was proposed and accepted as the focal topic. Several members of the breakout group were involved in active management, regulation, or mitigation/avoidance issues for this species.

Group outcome: The group wrote a general Goal, three Objectives, and proposed methods for implementing objectives for a typical hypothetical preserve. Given time constraints, objectives and implementation methods were described to varying degrees.

- GOAL**:** Ensure the survival of San Diego thorn-mint within 'X' preserve for 50 years

    - OBJECTIVE 1: Determine the San Diego thorn-mint spatial distribution by monitoring annually for 5 years
        - PROPOSED METHODS: Appropriate methods of mapping/monitoring (e.g. plots and GPS protocols) were thought to be best determined at the regional level. Coordinated data collection across preserves facilitates comparison across preserves, generates a clearer regional perspective and can improve reserve-level management.
          (Comments by participants: annual censuses may not be appropriate for all locations. Size of the population and intensity of threats at a particular location will influence count frequency.)

    - OBJECTIVE 2: Rank and identify threats to the specific SDTM occurrence at least annually or more frequently as appropriate for specific occurrence and threat
        - PROPOSED METHODS: Conduct habitat assessment using methods such as quantitative cover, qualitative assessment (trails/disturbance), include threats that might exist outside of occurrences

    - OBJECTIVE 3**:** *The group agreed that the focus of the third objective would be managing threats to extant populations but ran out of time to expand this objective.*

Process and Discussion points:

- As a first step the group worked on revising an existing manager's goal for SDTM, which was "Preserve, maintain and enhance SD thorn-mint". This goal was revised to have a time component and to focus on survival of SDTM. The revised goal was "Ensure the survival of San Diego thorn-mint on preserve X for 50 years." The time period of 50 years was chosen as this represents the duration of the current MSCP permit. However, the group recognized that population viability is not tied to permit duration and that ideally populations should be protected in perpetuity.Following agreement on a broad goal, five broad topics for objectives were proposed: 1) determine abundance/distribution within reserve, 2) identify (and rank/prioritize) threats to occurrences, 3) manage threats, 4) enhance, 5) monitoring/feedback. There was extensive discussion around the relative importance of these topics, how to implement the objectives, and whether there was inherent order or hierarchy to them. Example discussion points included: appropriate protocols for monitoring, duration of monitoring, prioritization of threat management versus determination of the abundance and distribution.
- The topic of threat assessment to individual populations led to a discussion of how different preserves are managed by different entities. In some cases, rangers conduct regular visits and therefore may have a better sense of the current threats. In other preserves, the sites may be visited only rarely by biologists conducting monitoring activities. Group members discussed how to write an objectives and implementation tasks for assessing threats to SDTM populations when the frequency of threat assessment varies.

- A recurring theme on the topic of both management and monitoring was a need for a conceptual plan or regional directives for SDTM to assist with determining specific management objectives and implementation methods. However, it was also noted that while invasive plants may represent a threat to all thorn-mint populations in the region, the particular invasive species acting as threats were noted to vary between preserves and even between populations within preserves. This highlights the importance for local flexibility to be built into to regional management tools such as conceptual models.
- One of the key discussion points for the group was that every objective may not need to be met for each reserve, e.g. If a site has already been monitored for 5 years, it may be appropriate to skip Objective 1. Likewise, for Objective 2, some sites will need the threats to be identified, and others will only need a ranking of already-identified threats.

Breakout Group 2: Wide Ranging Species and Connectivity

Participants:

Michael Beck
San Diego Director
Endangered Habitats League

Colleen Bradley-Kaltenthaler
Administrative Director
Volcan Mountain Foundation

Beth Dirksen
Park Ranger
County of San Diego Parks and Recreation

Nancy Frost
Associate Wildlife Biologist
California Department of Fish and Game

Megan Jennings
Biologist/PhD Candidate
U.S. Forest Service/San Diego State University

Karen Larsen-Gordon
Board Member
San Diego Tracking Team

David Lawhead
Staff Environmental Scientist
California Department of Fish and Game

Markus Spiegelberg
San Diego Area Manager
Center for Natural Lands Management

Melinda Taini
Senior Park Ranger
County of San Diego Parks and Recreation

Catherine Tredick
Postdoctoral Fellow
San Diego State University, IEMM

Background: Wide-ranging species were chosen as a break-out group topic as maintenance of ecosystem function (including functional connectivity of conserved lands) is one of the primary goals of the MSCP. Although maintenance of connectivity is generally considered on a regional scale, determining how to manage, monitor, and measure connectivity at the preserve level is essential for meeting these regional goals.

Chosen topic: Prior to developing specific goals and objectives, the group determined that SMART objectives for this topic needed to assess **current and historic levels of connectivity** (if possible), the **degree of movement and use** at specific linkages, and the **degree of gene flow across the landscape**. This information highlights the importance of considering physical and functional connectivity by pairing measures of gene flow or reproductive success with data on physical movement along corridors or linkages.

Given the broad context of connectivity and wide-ranging species, discussion was not limited to one topic or species. Focus was placed on determining relevant species for measuring connectivity, threats limiting connectivity in San Diego County, and specific targets for measuring connectivity. Because these issues differ between the eastern and western portions of the county, the group split into two subgroups and discussed connectivity issues in each of these portions separately.

Group outcome: The group wrote one general goal, 2 objectives, and proposed methods for implementing the 2 objectives for a generic preserve. Given time constraints, a limited number of objectives were developed and implementation methods were not completely fleshed out.

- GOAL**:** Conserve and manage habitat linkages and corridors in the preserve (or preserve system) to maintain and enhance trophic diversity and gene flow.

    - OBJECTIVE 1: Determine California gnatcatcher movement and distribution across and within a preserve in the next 3 years.

        - PROPOSED METHODS: Genetic methods and banding birds would be used to meet this objective.

    - OBJECTIVE 2: Assess the effectiveness of the landscape/corridors for permeability of bobcat movement between subunits in the next 3 years.

        - PROPOSED METHODS: Radio/GPS-collaring, track and scent stations, transects, and wildlife cameras would be deployed to meet this objective.

Process and Discussion points:

The group identified three **fundamental concepts** that informed goals and objectives for wide-ranging species and connectivity within the MSCP. These fundamental concepts included: 1) maximizing trophic diversity (predators, mesopredators, prey, etc.) across the landscape, 2) enhancing or protecting genetic diversity and gene flow, and 3) maintaining linkages/connectivity and "ecosystem function" across the landscape. There was general discussion on how "ecosystem function" should be defined in this context, and it was suggested that this term related to the degree or measure of trophic intactness (functioning food webs or predator/prey dynamics).

During this process, the group also identified a number of challenges and difficulties to determining SMART objectives on this topic. These included **defining terminology** (e.g., linkage vs. corridor), **choosing which species** to monitor, the **scale** at which monitoring should occur, and how connectivity at the **preserve-level relates to MSCP and the region**. Finally, it was unclear how to evaluate the relative **costs and benefits** of maintaining connectivity (e.g., providing corridors for non-native, invasive species versus native, focal species of concern).

The entire group discussed **which species would be good models** for studying connectivity and corridors in San Diego County.

- Plants were quickly dropped from the discussion in the interest of time.
- Mountain lions were removed from consideration because, while mountain lions may be the ultimate indicator of trophic "intactness," inference to other species may be limited since they are much more wide-ranging than most other animals in the county.
- Badgers were removed from consideration due to sample size issues (i.e., densities are too low in the county to provide enough information).
- Coyotes were removed from consideration because they are not sensitive enough to fragmentation to be representative of other large animals.

Once the group split, both subgroups independently decided on two focal species as good models for studying connectivity.

- Bobcats were selected as a focal species for both the east and west county subgroups because density and home range size throughout the county are most likely to be sufficient for evaluating corridor effectiveness and movements over relatively large areas. Bobcats also are more sensitive to fragmentation and imperfect movement areas than other species (e.g., coyote) and are likely representative of corridor functionality (i.e., an umbrella species) for a number of additional species.
- California gnatcatchers were selected by both subgroups because they serve as an umbrella species for CSS communities (Winchell and Doherty 2008) and genetic work is already underway in the county. They also are sensitive to fragmentation and urban effects such as roads. Sample size for this species is adequate as well, with over 100 pairs in the city of Carlsbad alone.
- Mule deer were selected as a third focal species by the east county subgroup due to the fact that they easily self-isolate into small habitat fragments and genetic information might illuminate chokepoints or barriers to dispersal.

The east county subgroup briefly discussed the **use of "pest" species as potential models** for monitoring and measuring connectivity.

- Feral pigs were discussed as a possible means of being able to assess corridor locations and effectiveness. Similarly, the gold-spotted oak-borer came up as a wide-ranging "pest" species that might be a good model to look at as well. The subgroup was never really able to pin down how that would work or what it would look like, however.
- What was particularly noteworthy about this discussion is that maintenance of effective linkages for covered or target species might mean maintaining these for non-target/unwanted species as well. Preserve-specific trapping or other management (e.g., raccoon trapping) might then be necessary to prevent impacts to the target, covered species of these corridors.
- Additionally, it is useful to look at creative and alternative routes to measuring and thinking about connectivity within the MSCP, including species we don't at first consider to be a valuable part of the system.

Both subgroups **identified 5 primary threats** that impeded or disrupted to connectivity and movement at the preserve level. These included **roads, development, corridor degradation, climate change** and **lack of stakeholder coordination**. The groups highlighted some of the factors within each threat that limit connectivity and discussed how these impacts can be measured or mitigated.

- Roads were identified as the biggest threat to connectivity in the largely contiguous areas (e.g., core areas around I-8, SR67, SR76, and SR78/79 in eastern San Diego County). The size of the road matters as larger roads (i.e., I-8) have the ability to completely decimate populations. Large roads with no undercrossings in the more urbanized parts of the county are also a major issue. Methods to measure the impacts of roads on connectivity include monitoring culverts, underpasses, and existing corridors using a variety of methods (roadkill, cameras, sign surveys, etc.). Developing a protocol for county road crews (or those who collect roadkill) to document relevant data (i.e., species and GPS location) as part of their collection routine would be valuable as well.
- In addition to roads, development of other infrastructure and land-use decisions pose major threats to connectivity as well. Many HOA and other easements in San Diego are not in

compliance for maintaining existing or potential corridors within the MSCP and should be forced into compliance as soon as possible.

- Degradation of natural corridors (e.g., riparian areas), including diversions (i.e., dams), urban runoff and other development issues, and non-native, invasive species (*Arundo*, pampas grass, tamarisk, etc.) is a major threat to connectivity. Urban corridors are often choked with invasives and are not suitable for use by many animals. Corridors and linkages in very urban environments tend to be very limited as far as options for movement by animals. For example, movement paths may be limited to a narrow greenway between 2 houses. The high edge-to-area ratio of urban fragments can negatively impact or limit animal movements as well.
- Land managers, planners, and biologists must not only consider historic and current linkages, but think about how these might change as the landscape changes with climate as well. Developing multiple, redundant corridors and linkages might be necessary in many cases.
- The east county subgroup expressed concern about the lack of coordination among landowners, homeowners, fire managers, planners, and biologists as a threat to maintaining connectivity. Communication and coordination among these stakeholders is key to maintaining the integrity and function of corridors and linkages within the MSCP. Everyone around a corridor must know its purpose and existence and the importance of properly maintaining it. Development of "corridor stewardship" groups in areas near linkages might be effective in assuaging this threat.

Breakout Group 3: Invasive Species

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City of San Diego

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Background: Invasive species were chosen as a break-out group topic because they pose a serious threat to ecosystems throughout San Diego County and are often the primary stressor in local preserves.

Chosen topic: Riparian habitat was chosen as the focal community because riparian corridors are often a conduit for invasive species. *Arundo donax* was chosen as the focal invasive plant for this exercise because more is known about its biology and how to manage it. Least Bell's Vireo was chosen as an example species of special status that *A. donax* could be negatively impacting in our hypothetical preserves.

Group outcome: The group wrote one overarching goal and two objectives for each of two different preserve scenarios.

- GOAL: Restore and enhance ecosystem function of the riparian corridor to preserve special-status plant and wildlife species

    - SCENARIO 1: The preserve is large and isolated. There are 100 acres of *A. donax* present and no *A. donax* upstream. The riparian habitat historically supported Least Bell's Vireo.
        - OBJECTIVE 1: Eradicate 100% of *A. donax* within the preserve within 5 years.
        - OBJECTIVE 2: Re-vegetate 25 acres of *A. donax* control areas with willow species and natural community associates that could support Least Bell's Vireo within 7 years of initial *A. donax* treatment.

- SCENARIO 2: The preserve is in a network of preserves (which are outside of our jurisdiction). There are 10 acres of *A. donax* present and there is also *Arundo* upstream. The riparian habitat historically supported Least Bell's Vireo.
  - OBJECTIVE 1: Reduce coverage of *A. donax* to less than 20% coverage within 2 years of initial treatment. Maintain less than 20% coverage in perpetuity.
  - OBJECTIVE 2: Re-vegetate at least 8 acres of *A. donax* control areas with willow species and natural community associates that could support Least Bell's Vireo within 4 years of initial *A. donax* treatment.

Process and Discussion points:

- The group focused considerable discussion on developing the best, most precise language for the goal. In particular, "enhance" was added to capture situations in which some functional habitat is already present but can be improved; "restore" was used to signify a larger process of bringing ecosystem function back to a place where it was formerly absent. "Riparian corridor" replaced the term "watershed" since it more accurately reflects the particular habitat we were envisioning (as opposed to the many types of habitat that are present throughout a watershed). "Special status" was used to describe target species instead of "native" or "MSCP listed" because the former is too broad and the latter too narrow in scope.
- The group acknowledged that this goal could easily cascade into numerous objectives beyond the scope of invasive species. However, the objectives generated here focus solely on invasive species.
- Objective 1 varied between preserve scenarios. In Scenario 1, eradication of *A. donax* is possible because there is no upstream source. However, in Scenario 2, eradication is much less likely because *A. donax* will be carried onto the preserve continuously from upstream sources. In this case, reduction and on-going maintenance is the more feasible option. In addition, because the area covered by *A. donax* in Scenario 2 is substantially less than in Scenario 1, the group decided that less time was needed to accomplish the objective. However, management of *A. donax* will continue in perpetuity. Specially, when/if *A. donax* cover reaches 20%, management actions to reduce coverage will be triggered.
- Considerable discussion revolved around the wording of Objective 2. Specifically, "re-vegetate" is used to mean actively plant native species. The idea is to kick-start the re-vegetation process while making the assumption is that natural native re-vegetation will occur also. "Willow species and the natural community associates" was chosen because this native riparian habitat is also good habitat for Least Bell's Vireo. The word "could" is used in this objective so that if Least Bell's Vireo are *not* found in this restored habitat, the objective did not fail. The objective is to create *potential* Least Bell's Vireo habitat, rather than occupied vireo habitat. The group felt that this was an important distinction that had both practical and regulatory ramifications.
- Objective 2 also varied between preserve scenarios. Because *A. donax* covers far less area in Scenario 2 than in Scenario 1, re-vegetation of the entire *A. donax* control area is feasible in Scenario 2. "At least 8 acres" corresponds to the "less than 20% coverage" from Objective 1. If more than 80% of Arundo control areas are cleared of *A. donax*, more than 8 acres will be re-vegetated. This time frame of 4 years (as opposed to 7 years in Scenario 1) reflects the relatively small area to be re-vegetated (8-10 acres) and the relatively rapid growth of the riparian species under consideration.

Breakout Group 4: Stewardship, Education, and Outreach

Participants:

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Background: Stewardship, Education, and Outreach was chosen as a break-out group topic largely in response to feedback received from potential participants prior to the workshop. Addressing stewardship issues such as public access is key to successful conservation programs, as stewardship and cultural and natural resource monitoring and management are inextricably linked.

Chosen topic: The group focused on topics directly and indirectly related to public access. Education and outreach on both cultural and natural resources at a preserve was recognized as an important complement to work that focused directly on controlling access.

Group outcome: The group wrote an overarching theme for its goals and objectives as well as two goals and three objectives.

THEME: Provide, through stewardship, the environment and the experiences for which the Preserve was originally created.

- GOAL 1**:** To control access by providing sustainable and appropriate access to the preserve that maintains and/or enhances the conservation values of the natural environment while providing compatible uses.
    - OBJECTIVE 1: Close trail(s), using natural and artificial barriers, that access naturally and culturally sensitive areas within 1 to 5 years (in relation to the need/ size of the preserve).

- GOAL 2**:** Develop a public education and outreach program about the natural and cultural resources and compatible uses within and adjacent to the preserve.
    - OBJECTIVE 1: Procure, install, and maintain informational kiosks at all approved access points within 1 to 5 years.
    - OBJECTIVE 2: Over a five year period, develop a volunteer program in which preserve management provides training to volunteer docents/tour guides/support staff.
        - Implementation task: Docents to give at least 1 tour per month, volunteer staff will work 1 event per month and conduct at least 4 monitoring patrols each month.

Process and Discussion points:

- The group assessed several of their objectives in light of the SMART criteria (or a subset thereof). The group determined that Objective 1 (under Goal 1) is **m**easurable because patrols could monitor the barriers using staff, cameras, and/or pressure sensors. In addition, the group identified three assumptions underlying this goal: 1) trails and access points are already mapped, 2) sensitive areas are already identified, and 3) financial resources are available.
- Objective 1 (under Goal 2) was also deemed **m**easurable because staff can confirm kiosk installment and monitor their maintenance. It was also deemed **a**chievable because Eagle Scout projects could be utilized to implement the project.
- Objective 2 (under Goal 2) was also determined to be **m**easurable because the number of volunteer hours can be measured. The objective is also **r**esults-oriented because it would increase protection of resources and enhance both the resources and educational experience.
- In addition, the group discussed the important of public support for successful management. Signage and education is needed as well as fencing and enforcement. Neighborhood outreach- education and volunteer programs- is important as it can turn ignorance into awareness.

Breakout Group 5: Ecosystems and Natural Communities

Participants:

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Tracie Nelson
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Background: Ecosystem processes and natural communities were chosen as a breakout group topic because maintenance of ecosystem function is one of the primary goals of the MSCP. Although maintenance of ecosystem function is generally considered on a regional scale, determining how to manage, monitor, and measure function at the preserve level is essential for meeting these regional goals.

Chosen topic: The group chose to focus on composition of natural communities across the landscape rather than select a single system or community.

Group outcome: The group wrote two general goals, and four objectives for a generic preserve. Given time constraints, a limited number of objectives were developed and implementation methods were not completely fleshed out.

- GOAL 1: Maintain long-term net sub-regional habitat value

- GOAL 2: Ensure persistence of native-dominated vegetation mosaic

    - OBJECTIVE 1: Develop baseline community-level (CA Stand. Veg. Class.) as part of RMP preparation
        - Identify recognized threatened vegetation communities in need of management action (i.e., restoration, invasive species control, access control, etc.)

- OBJECTIVE 2: Annually map and maintain list of invasive plants of management concern (that threaten persistence of native dominated vegetation mosaic)
  - Some participants felt the parenthetical should be incorporated as part of the objective because annual mapping may not be necessary in all cases. It may be beneficial to map the most degraded areas (requiring substantial financial and personnel resources to restore) annually in order to properly budget for restoration efforts and to track management needs and efficacy over time.

- OBJECTIVE 3: Annually prevent expansion or reduce cover and distribution (# of occurrences) of invasive plants of management concern

- OBJECTIVE 4: Using available information (urban/development edge areas, fire history, roads, geotech (landslide potential), rainfall, land manager knowledge), identify and map areas of high risk of degradation and/or conversion due to disturbance every 5 years or immediately following a disturbance event (fire, flood, landslide).
  - This objective would include target management actions to ameliorate threats in identified areas
  - Some participants felt that mapping high risk areas would not be useful at some sites. High risk areas typically involve preserve edge, trails & roads, and may already be explicitly demarked on maps and management plans. In these cases, unnecessary mapping may drain already limited budgets. One solution to this would be if the objective were re-written from "identify and map" to "identify and monitor."

Process and Discussion points:

The group identified a list of **processes** and **threats** that the participants believed were central to developing the goals and objectives listed above. This information represents best available science and the group's expert opinion and experience.

- The group identified **six ecosystem processes** that were critical to meet the two overarching goals of 1) maintaining habitat value over long time periods and 2) ensuring persistence of native-dominated vegetation mosaic . These processes included fire, hydrology regime, pollination, succession, nutrient cycling and colonization/dispersal.

- The group also identified **six primary threats** to the stated goals which included altered fire regime, urban runoff (erosion, downcutting, water quality), invasive species (plants, wildlife, domestic pets), increase in climate variation, inappropriate recreation and human use, and faunal simplification.

Summary

To evaluate the utility, relevance and overall success of the workshop, IEMM distributed an anonymous survey to solicit feedback from workshop participants. Based on feedback from nearly half of the workshop participants, ***the workshop was very successful in meeting its primary objectives***. Namely, a broad group of managers, planners, and rangers working in the San Diego MSCP and the San Diego Conservation Planning area were able to 1) come together to learn how to develop SMART and robust goals and objectives and 2) work collaboratively and gain hands-on experience in developing and writing concrete goals and objectives for a variety of locally relevant management issues. Participants acknowledged the usefulness of learning about SMART criteria and stated overwhelmingly that the criteria would be an integral part of their management and monitoring programs in the future. They also rated the material covered in the workshop as relevant or extremely relevant, particularly the example goals and objectives that were reviewed in the introductory presentation (see Appendix I).

The perspectives of the local land managers had many common themes, including the importance and need for close collaboration and communication within the MSCP and related stakeholders tasked with resource management. There was general consensus that meeting management challenges of the MSCP could be more effective and efficient with increased sharing of knowledge, ideas, and expertise. Additionally, managers acknowledged that there needed to be a stronger link between regional goals and preserve-level monitoring and management activities. It is clear that some of the monitoring and management activities identified in various MSCP documents do not translate clearly to on-the-ground, small-scale management at the preserve level. Furthermore, there was recognition of the ongoing challenge between how to manage ecosystems or communities across the MSCP system as a whole rather than focusing on the species-by-species approach that currently dominates monitoring and management in San Diego County.

Breakout sessions were extremely productive and generated a lot of valuable discussion regarding the process of developing goals and objectives. Some groups focused their discussion on particular habitat types or species, whereas others were more generalized. Participants in all groups gained valuable experience in writing concrete goals and objectives for issues of concern at the preserve level. This exercise is the first in a series of workshops designed to provide technical support and expertise to individual preserves and the management community. The IEMM will host another workshop on conceptual models in February which will build upon outcomes of this workshop and move to the next step in how to improve monitoring and management: developing conceptual models. Conceptual models link goals and objectives to specific monitoring targets and management actions. This second workshop will provide tools for managers to improve their ability to define relationships and build conceptual models for a variety of species, communities, and systems.

The aim of this workshop was to focus attention on the process and importance of developing and writing goals and objectives for monitoring and management. One of the central messages from the workshop was the iterative nature of this process. Goals and objectives need to be re-assessed and reviewed over time. Objectives that meet SMART criteria provide managers with an opportunity to critically evaluate revise and improve existing objectives. These objectives also serve as the anchor by which information gathered or data collected through monitoring can be used to improve management efficiency, efficacy and outcomes.

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APPENDIX 4 – APPENDICES FROM THE GOALS AND OBJECTIVES WORKSHOP REPORT

Developing and Refining Goals & Objectives for Monitoring and Management:

Building and implementing an integrated framework for monitoring and management in San Diego County

Proceedings from a workshop held
Wednesday, November 2nd, 2011, Mission Trails Regional Park

Table of Appendices

I) IEMM Goals & Objectives Workshop – Feedback

Survey Released: 11/4/11
Results Collated as of 11/21/11

Shortly after the workshop, we distributed a survey to all workshop participants requesting feedback on both the workshop's content and structure. Twenty-two respondents completed the survey. Questions and responses are below.

1. Which of the following best describes your job? (multiple answers allowed)

	Response Percent	Response Count
Planner	19%	4
Land/ Resource Manager	9.5%	2
Research/ Monitoring	28.6%	7
Boots on the ground	23.8%	5
A little bit of everything	**47.6%**	**11**
Other (please specify)	9.5%	2
		23 total

2. Which of the breakout groups were you in?

	Response Percent	Response Count
Rare and endemic species	20%	5
Corridors and connectivity	15%	3
Invasive species	**30%**	**7**
Stewardship management, education, and outreach	20%	4
Ecosystem and natural communities	15%	3
		22 total

3. What was your overall impression of the workshop?

	Response Percent	Response Count
Excellent	30%	7
Good	**55%**	**12**
Fair	15%	3
Unsatisfactory	0%	0
		22 total

4. How would you rate the applicability and relevance of the material covered?

	Response Percent	Response Count
Extremely relevant and useful	**45%**	**10**
Relevant and useful	**45%**	**10**
Somewhat relevant and useful	10%	2
Not relevant or useful	0%	0
		22 total

5. Please comment on the workshop content. What were the most relevant topics for you? What were the least relevant?

1) General info was good, but couldn't create actual goals and objectives
2) Defining what is a goal and what is an objective and quantify
3) SMART
4) Organizing aspects; SMART meter
5) Review of the SMART criteria was useful. Mention of other efforts at developing G/O and their average SMART rating was eye-opening. The over-emphasis on how hard G/O are to develop and implement was depressing - next time end with "But we have developed a training method that will help make it easier". The presentations by the land managers should have focused on their use of goals and objectives, instead it was more rambling and not very instructive. It would have been nice to have someone from the literature or from the FWS refuges who authored the guidebook talk about developing G/Os.
6) all pieces had some relevance
7) Ecosystems were the most relevant. Stewardship management was the least relevant.
8) Developing 'smart' goals and objectives was very timely as I am participating in the development of an HCP which includes goals and objectives.
9) The Workshop was awesome. All topics were relevant. I learned a lot and it helped me see the whole picture. I would be interested in attending future workshops.
10) The presentations were good but I do not find breakout groups to be a productive use of time- sort of like writing by committee. The question I was left with was whether the goal of the workshop was to educate people or was it to advance refinement of goals and objectives for a monitoring plan? If the former, the workshop was okay at meeting the objective but could have been shorter. If the latter, I do not feel much was achieved.
11) Most relevant was the SMART process for determining the appropriateness of objectives. Least relevant was the break out group sessions.
12) I was a little confused about the specific purposes of the breakout groups. Was it just to get us thinking about how we would set goals/objectives, or to actually work on the specific goals/objectives we would like to see in the final plan.
13) It was all relevant. The best part for me was the discussion about SMART goal/objective setting. See later comments about what I felt was missing.
14) Hands on. I'd like to hear more from the land managers
15) The most relevant were the morning presentations, and particularly the material presented by IEMM. EHC presentation was the most useful of the land managers - gave a good overall context. Breakout group topics were highly relevant, but results could have been more useful with different group makeup and structure.
16) All topics were very relavent!
17) Most relevant: evaluating objectives based on smart criteria powerpoint Least relevant: I'm not sure, but I have ideas that could make it more relevant/useful to participants
18) The most relevant topic was the discussion and exercise of defining and developing goals and SMART objectives. Many of the "measureable tasks" are known and can vary greatly depending on the preserve (as many groups reported). The process of goal and objective development can be standardized and this workshop did a great job showing that. While not the least relevant, the link between the products of this workshop and the regional Management Strategic Plan could have been better explained. It made me wonder if the G/Os of the overall strategic plan have undergone the SMART evaluation (presuming they have been clearly defined in the first place).
19) The intro session was very helpful and well thought out. All topics were relevant.

6. Thinking back on the morning presentations, how would you rate each of the following elements?

	Excellent	Good	Fair	Unsatisfactory
Overall introduction	36.4% (8)	**54.5% (12)**	9.1%(2)	0% (0)
Example goals and objectives	**54.5% (12)**	36.4% (8)	10% (2)	0% (0)
Informal presentations by land managers	22.7% (5)	**50%(11)**	22.7% (5)	5% (1)
Presentation on the regional context of this work	22.7% (5)	**59.1% (13)**	18.2% (4)	0% (0)

7. After hearing the presentations, how likely are you to use and apply the SMART criteria in development or evaluation of your own objectives?

1) very
2) yes, I would use it.
3) Very likely.
4) Likely but overall there were no good example of how to use SMART criteria for on-the-ground goals and objectives that are tied to conceptual models on current knowledge of species, habitats and processes in SD county
5) I already have written goals and objectives using your system for an interpretive trail at the outdoor school
6) 100% likely
7) Very likely
8) very likely
9) Very likely and have immediate ability to apply to current project
10) Very likely
11) This was a strength of the workshop and should be applied.
12) Very likely to use SMART.
13) A good tool that I would use.
14) Very. I will implement this method in all future goal/objective development.
15) This is a new concept to me. I am likely to use Smart criteria.
16) Very likely.
17) Very
18) I will definitely try and implement the criteria; application will be immediate.
19) Very likely!
20) Very likely- however, it would have been more useful to talk more about how to develop SMART objectives while maintaining flexibility or when baseline info is absent yet the workplan requires you to develop objectives that extend beyond gathering baseline info
21) Extremely likely - we already use the SMART system for derivation of organizational and professional development G/Os at my workplace.
22) Very likely

8. In your breakout group, what is your sense of the tradeoff between structure and flexibility? Did you want more direction? Or did you feel it was important to have flexibility?

1) I think our participants are strong enough to create their own flexibility within a structured system if desired
2) More explanation for how to work the problem
3) Slightly more structure would be good.
4) Structure was lacking but what was lacking even more was critical information needed to develop scale specific goals and objectives for the selected topic and a conceptual model that helped inform the development of the scale specific goal(s) and objectives.
5) flexibility in the beginning was good because it forced people into a leadership role; the more structured wrap up towards the end was good
6) We spent a lot of our time creating an example reserve and scenario to write the specific G/Os. It would have been better if SDSU had provided example reserves, scenarios, species of concern, conceptual models, etc. Also, it would have been good to have a coach/expert/sometone who writes G/O for a living leading our group. Also, how about having some handout with spaces to fill in (maybe on how the objectives are SMART)? Instead we spent too much time re-writing our G/O for the presentation.
7) Our group had a hard time deciding which direction to start in, and used about half the time hashing that out....perhaps a bit more structure could help.
8) We could have used more direction in order to make a stronger connection to how the information would actually be used in the future.
9) I would have preferred more direction. Our group talked in circles b/c we did not have a collective set of assumptions. If the object was to show how hard it is to create goals and objectives, then we were successful. If the object was to practice creating 'smart' goals and objectives, we were not successful b/c of the lack of a common starting point. If we'd had a set example and were just developing 'smart' goals/objectives, I believe we could have achieved this as a group.
10) Because this workshop was my first experience with this kind of thing i would like more direction, but i know it is important to be flexible when working within a group scenario.
11) While flexibility has its merits it does not lead to a productive use of time.
12) We needed more direction. People were all over the board in regards to where we should begin and which objectives to create. I realized that most people did not have any idea on how to formulate objectives, tasks or methods. They had little land management experience, (i.e., application of tasks and methods based on the formulated objectives).
13) Perhaps a little too much flexibility.
14) Some people got hung up on wanting a very specific situation. Based on my experience, in real life you are often asked to develop goals/objectives for a preserve for which you don't have a detailed threats analysis, so you really can't get more specific until you've implemented the management plan for a year or two. Rather than include a discussion of the difference between different types of preserves (e.g., big or small), for me it would have been more helpful to compare specific info vs. relatively little info (how would goal/objectives differ in those situations? what is the best way to deal with the lack of specific threats and/or species information?).
15) We could have used a bit more direction or details specific to our scinarios.
16) Flexibility is important knowing that funding and staffing are limited a lot of the time. However, it's better to have more direction because this seems to be a common request from the wildlife agencies.
17) Flexibility.
18) Desired a little more structure. Also would have been useful to pre-assign groups so the 'institutional knowledge,' experience levels, and types of experience of participants were more evenly distributed.

19) I think more direction would have been helpful due to the various ideas and trying to agree on those ideas. Just from the working group I was in, I noticed that there needed to be a facilitator who could assist and guide the group in the right direction. Alot of time gets wasted from people not listening to each other and coming to mutual agreement on certain ideas.
20) Flexibility is good, however, I think more time would have been spent developing goals and objectives if less time was spent discussing the hypthetical situation so hypothetical situations should be provided to avoid that
21) I liked the lack of scenarios and the resulting flexibility because it forced the group to define parameters/assumptions and revealed how those variables could impact G/O development. Please see comment #9 for more on timing of breakout sessions and potential guidance.
22) Flexibility is key. At first it seemed that we weren't on the same page, but then as the conversations developed, it all came together.

9. What are your opinions on the structure of the workshop? Do you feel the amount of structure in the workshop was appropriate? How do you feel about the balance between full group sessions and the breakout sessions?

1) Pretty good
2) Well balanced
3) While both sessions were somewhat informative, they were like many other workshops that provided generalities on how to do things, they didn't result in actually producing a product that could be used by one or more of the participants.
4) appropriate on both
5) Many people had to leave around 2:30-3:00pm and did not get to participate in the presentations at the end. Perhaps less time in the breakouts would have been better.
6) Good balance
7) The structure was appropriate and the balance was good between the sessions.
8) The structure was good. I think perfect amount of time for each. I liked that it was one day and that there was background info provided to get us started.
9) The structure of the workshop was very appropriate. I feel more is accomplished with smaller groups so i loved the breakout sessions.
10) Per comment above, I do not feel that breakout sessions deliver enough educational value to warrant the time expenditure.
11) I think the break out sessions needed more structure and guidance, but the overall presentation was really good and easy to follow. I found SMART to be very, very useful and will use it to refine the objectives that I recently created for several HMPs.
12) Half and half is about right.
13) I really liked the balance between the full group vs. break out session. I also liked that the initial presentations included several specific examples relevant to SD County. The facilitator did try to keep us from going off track, but I think stronger guidance would have been helpful.
14) I thought it was a good even balance.
15) Excellent
16) Balance between full group sessions and breakouts felt appropriate. Would have been interesting to go through one full example as a group (with IEMM) before initial breakout session.
17) The amount of structure was appropriate, except for each group having a permanent facilitator. I like the breakout sessions, but again there was a need for a guiding facilitator.
18) The balance was good. However, I think the workshop would have been more useful if in the breakout sessions, instead of developing SMART objectives for a hypothetical situation, land managers could discuss the challenges they face in developing goals and objectives for the preserves

they are managing and work together as a group to develop goals and objectives for those real life situations.

19) Good balance. Maybe a little more time before lunch with the breakout groups so participants didn't feel the need to work through lunch to maintain momentum. It might also be helpful to more clearly articulate where each group should be before breaking (e.g. "we suggest you try to derive one goal and one objective before lunch so you can get a feeling for the process, then build on that first G/O with others after lunch.")
20) Good. I always like small breakout groups, some of the groups seemed to large. the intro session is necessary to get everyone on the same page.

10. How interested are you in participating in future workshops (such as the upcoming workshop on conceptual models)? Are there any other topics you would like us to host a workshop on? Any additional comments you'd like to share?

1) Very interested in future conceptual model workshop
2) No
3) I'd be very interested in attending future workshops.
4) The workshop was an opportunity missed. There was great participation by many of the land managers with varying levels of responsibility, but the workshop wasn't geared to help the various levels develop goals and objectives that could be implemented and benefit preserve management based on their levels of responsibility. The participants were not provided with much in the way of take home materials that they could utilize in their day-to-day implementation of improved preserve management. There seemed to be a significant lack of planing with key personnel responsible for preserve management decision makers to ensure that the workshop actually focused on developing relevant goals and objectives that might actually carryover into on-the- ground preserve management. The preserve management entities invested 100 hrs and $1,000s in sending their employees to the workshop and its unlikely that they received the appropriate return on their investment in this effort. Probably the biggest benefit of the workshop was having the rangers from the County talking with the rangers from the cities about day-to-day management issues, but the forum didn't maximize that opportunity and does not provide for on-going dialogue and mutual learning.
5) This workshop was useful for land managers who have never had to develop G/O or who manage without thinking about goals and objectives. It was a good reminder for folks who do develop G/O to use SMART criteria - but we could have done without an all-day session.
6) Coming from the east county (Julian) area, much of the pull and focus of the group seemed to be toward more westerly areas of the county.
7) Put together a database (species lists, maps, eradication programs, etc..) that all interested parties could contribute to, have access to, and update regularly. Consider the County of San Diego's Office of Emergency Services WebEOC system:
http://www.sdcounty.ca.gov/oes/WebEOC/oes_sr_webeoc.html
8) Very interested in participating in upcoming workshops. Thank you for hosting these events. Even though these are hard topics, I feel we are making progress as a region to be better at what we do and you help us get there.
9) I am very interested in upcoming workshops.
I am interested in the progress that is being achieved but would value it more if the PI's took a leadership role and presented actual goals and objectives or conceptual models that could be discussed relative to their strengths and shortcomings. The various stakeholders could then discuss how they do or do not meet their objectives which would provide the basis for refinement.
10) I am very interested in upcoming workshops. Perhaps indicating the differences between objectives, tasks, and methods. People didn't seem to understand how these differed.
11) I am interested in participating in future workshops.

12) I am interested in participating in all upcoming workshops. Most critical to me would be a discussion of how regional goal setting,regulatory requirements, funding availability and preserve-specific goal setting tie in together. For example, some folks feel that since there is regional monitoring for CAGN, there is no need to do any CAGN surveys at the preserve level. However, (1) there is a regulatory requirement to conduct these surveys, and (2) preserve managers still want to know what is going on with CAGN on their preserves. Another example: A regional vegetation monitoring protocol has been developed for scrub habitat. How can this be used at the preserve level? If your preserve size/funding only allows 2-3 sample plots on your preserve, is this enough of a sample size to really tell you anything or should there be a different way to monitor vegetation community condition at the preserve level? Again, wanting to understand vegetation changes regionally (big picture) is a different question than wanting to know if your preserve (e.g., what you are responsible for) is functioning well. And of course, in order to develop goals and objectives, you have to determine what your question is. Some folks feel that you can set up a trickle up system, as originally proposed, whereby you can feed preserve-level info into a database to inform regional-level analyses. i don't think that is always possible. Another example: some folks would say that if you can't do statistically valid monitoring, it's not worth the effort. Realistically, however, many land managers don't have a statistics background, the preserve is too small for a valid sample size, funding doesn't allow for this level of analysis, etc. How should monitoring be conducted in these situations? These are the types of questions that, in my mind, are critical.
13) I would attend future workshops. I would like to learn more about recreation conflict and user satisfaction in nature preserves where access is allowed.
14) Very interested.
15) Very interested
16) Very interested in the conceptual model workshop. If you use the breakout group structure, it would be helpful to have specific examples for modeling, along with appropriate background information on species, habitat ecology, threats, etc. so that participants don't spend time trying to come up with scenarios and can instead get right to the process (which is what we need to work on). It would be helpful to have multiple examples with varying levels of background information to mimic real life situations, and it would be ideal if groups were able to move through more than one type of example.
17) I am very interested in future workshop participation. The topics covered in this workshop are all very significant and can be difficult to cover in just one day, but they are all very important and getting everyone to understand why they are so important is a message that needs to be stated and emphasized as part of the workshop.
18) Answering #10 above, I am very interesting in participating in future workshops, especially if they are at Mission Trails Park! My only additional comment is that I thought all of the IEMM representatives did a fantastic job with everything!! The opening presentations were clear and concise, the organization of the event was smooth, and the food was plentiful - all very important.
19) I'm interested in the conceptual models and other workshops.

II) Break Out Session Guidelines

Develop a set of goals, objectives, and example implementation tasks (e.g. ASMDs, tasks, strategies, conservation actions) for your topic.

It may be useful to develop these goals and/or objectives under a range of implementation challenges including:

1) Large, isolated preserve
2) Collection of small preserves
3) Single small preserve
4) Preserve within a network of preserves

III) Goals and Objectives – Defined

Goals should be broad but concise visionary statements that set overall direction for monitoring and management. They may encompass a range of possible monitoring and management approaches.

Objectives (and implementation tasks) should be concrete and measurable to allow evaluation of progress toward meeting overall goals. Often multiple objectives are needed to meet a single goal. An excellent definition comes from Schroeder 2009.

> *Objective.* A concise statement of what we want to achieve, how much we want to achieve, when and where we want to achieve it, and who is responsible for the work. Objectives derive from goals and provide the basis for determining strategies, monitoring refuge accomplishments, and evaluating the success of strategies. Make objectives attainable, time-specific, and measurable.

<u>Strong Objectives should satisfy three criteria:</u>

1) all objectives must be specific, measurable, achievable, results-oriented, and time-fixed (SMART) – SMART criteria on the back of this page
2) objectives must be based on sound, documented scientific information; and
3) the rationale for each objective should be clearly documented and explained. (From Schroeder 2006)

IV) SMART criteria (US FWS)

Specific **M**easurable **A**chievable **R**esults-oriented **T**ime-fixed

Specific. Avoid ambiguity by wording objectives clearly. A clearly worded objective is easy to understand and the meaning is difficult to misinterpret. Specificity results by including WHO will do the action, WHAT we will do, WHEN and WHERE we will do it, and WHY we will do it

Measurable. Objectives should contain a measurable element that we can readily monitor to determine success or failure. Otherwise, you cannot tell if the strategies employed are appropriate, when we have met an objective, or if we should modify it.

Achievable. Objectives, no matter how measurable or clearly written, must be achievable. If you cannot resolve constraints on achieving an objective, then you must discard or rewrite it

Results-oriented. Objectives should specify an end result.

Time-fixed. Objectives should indicate the time period during which we will achieve them, so as not to be open-ended

From Adamcik et al. 2004.

V) Breakout Group Reporting

You will be presenting your goals, objectives, and tasks to the larger group and discussing issues and solutions identified within each break-out group. Thus, be sure to document your decision making process so that you can share an explanation of your rationale to the larger group. Specifically,

- What factors were important in developing your goals and objectives?
- Did your goals and objectives change depending on the type of preserve? *(see front page)* Why or why not?

Other questions to consider as you work through this process:

- What are the challenges/difficulties for writing goals and objectives for your topic?
- How does landscape change (climate change, fire, habitat degradation/ restoration) fit in to developing your goals and objectives?
- How do you prioritize different goals and objectives for a given preserve?
- Can you have multiple goals and objectives for the same management target?
- Can you have one goal and objective for multiple management target?

VI) Potential Goals and Objectives form EMP Working Group 2012 Recommendations [1]

Habitat Restoration and Invasive Control

- Native Grasslands
- Coastal sage scrub
- Associated uplands around bays and lagoons.
- Maritime succulent scrub/Coastal bluff scrub
- Vernal pools

Species-Specific Management

Species	General Management Issue to be Addressed
California least tern	Reduce threats and improve structure of nesting habitat to support > 150 nesting pairs
Western snowy plover	Maintain and enhance nest sites where associated with California least tern
Coastal cactus wren	Reduce predation by managing vegetation. Maintain and enhance nesting habitat
Golden Eagle	Repair/replace nests and/or install nest ledges. Reduce threats.
Northern Harrier	Create new nesting opportunities. Maintain and enhance existing nesting areas.
Tricolored blackbird	Maintain and enhance nesting areas/water at or near historic nesting sites
American badger	Restore and enhance known nest burrows
Quino checkerspot	Restore and expand suitable habitat
Otay Mesa mint	Increase number and size of populations
California Orcutt's grass	Increase number and size of populations
Spreading navaretia	Increase number and size of populations
Thread-leaved brodiaea	Increase number and size of populations
San Diego thornmint	Increase number and size of populations
Dehesa beargrass	Increase number and size of populations
Nutall's lotus	Increase number and size of populations
Short-leaved dudleya	Stabilize population have shown declines. Reduce threats
Orcutt's spineflower	Increase number and size of populations
Willowy monardella	Increase number and size of populations

Habitat Maintenance, Access Control/Management and Volunteer Coordination

Regular day-to-day habitat maintenance, management of public use combined with monitoring of effects on species and habitats, and the coordination of volunteer programs to implement management actions. This includes signage (both interpretive and cautionary), education, erosion control, culvert maintenance, fencing, patrolling public use, costs related to volunteer coordination, law enforcement, and efforts to remove garbage in existing preserve systems to allow habitat areas to recover. Eligible projects also include data collection/monitoring to:

- Determine the effects in public use on species and vegetation communities
- Track types, quantity, and seasonality of public use
- Assess areas for compatible public use prior to allowing access.

VII) IEMM Pre-Workshop Survey

Survey Released: 9/30/11
Results Collated: 10/27/11

Prior to hosting the workshop, we broadly distributed a survey requesting input on potential workshop topics. We received responses from 32 potential participants. Questions and responses are below.

1. Which of these topics would you identify as most interesting and relevant for you?

Topic	Response Percent	Response Count
Rare and endemic species (e.g. Otay tarplant or fairy shrimp)	43.8%	14
Corridors and connectivity: highly mobile wide-ranging species (often species of conservation concern)	34.4%	11
Invasive species (perrenials like Arunso and annuals like non-native herbs)	46.9%	15
Stewardship management (e.g. public access, trail maintenance)	37.5%	12
Regional/landscape scale (setting and coordinating goals across scales and jurisdictions)	56.3%	18
		32 total

2. Do you think any of these topics are unsuitable?

1) No. ***(11 different respondents replied "No")***
2) DPR allows public access within our Preserves and we have been analyzing trail development through our Public Access Plans and subsequent environmental documents. I don't believe public access should be considered a threat to species and vegetation communities when planned with the goal of less than significant impacts.
3) No, they all seem appropriate and I had a hard time selecting a most-interesting.
4) No, all the topics are relevant to the stated goals of the workshop.
5) No, they all seem suitable to me.
6) No, but sometimes I find when there are too many topics, discussions get more difficult
7) No, these topics should be relevant to all land managers.
8) No, all are very important. As a land manager I consider all of these items throughout the year. In my opinion, they are all interconnected.
9) All of them are suitable
10) NCCP is about protecting and managing natural communities so one doesn't have to conduct species by species monitoring and manangement for all species. Perhaps the first two topics could be changed to 1. species needing species specific M&M and 2. species and ecological processes for which natural community M&M is sufficient. The first would capture the rare and endemic species. the second would replace wide-ranging highly mobile species with natural communities M&M as envisioned by the NCCP planners.

3. Are there other topics related to setting and constructing goals and objectives that you feel this workshop needs to cover?

1) Fire, fire frequency, and ecological response.
2) Public participation in habitat restoration and conservation initiatives. More precisely, appropriate ways to involve the public and encourage the participation of volunteers in open space mgt. & projects.
3) Utilization of an existing data collection network, i.e. the San Diego Tracking Team.
4) Conservation of habitats (CSS, riparian, etc.) - a more broad-based approach than just individual species (a multi-species approach).
5) Department of Parks and Recreation has to address Preserve level management and monitoring. Will we be discussing the revisions to monitoring protocols of the MSCP covered species in this workshop? DPR is moving forward with monitoring within our Preserves and an update on the revision of the monitoring protocols would be helpful. How are we as a group moving forward? Will this workshop assist in revising the protocols?
6) Site-specific/preserve level scale
7) Include management for or of animal species,e. g., bull frogs, salamaders and birds that are not yet listed.
8) Consider: ecosystem processes; Decision-making process, especially with respect to multi-agency and NGO collaboratives; CLimate change; species and habitat vulnerability; Social science link of some sort.
9) Monitoring threats and stressors
10) No
11) None that come to mind.
12) Although likely already considered, if not, stewardship management should include public outreach/education. Although habitat management is implied under the first three topics presented above, a separate call out may be warranted.
13) Just getting all land managers on the same page would be nice. In other words, to the extent possible, getting everyone to monitor in a similar manner so that trends can be developed and analyzed.
14) I'm interested in exploring preserve-level vs. regional goal setting.I assume that is part of the one I checked?
15) Probably fall under stewardship: Education and Community Outreach
16) Goals and objectives need to be crisp enough that it will be clear when they are not being achieved and clear enough to justify raising the resources and/or making the policy changes needed to achieve them
17) Is there any intention to have a stressor based monitoring approach? If so then maybe this topic could be addressed more explicitly.
18) No.
19) Heirarchal structure of Goals and objectives, which could be discussed under hte regonal/landscape scale.
20) Which newly developed sensitive species monitoring protocols (from SDMMP and related), if any, are appropriate for land managers to implement on the preserves now?
21) Yes - establishing goals for comprehensive, region-wide monitoring and management, not just preserve-level monitoring and region-level management.
22) Major misunderstanding of the differences between goal and objective. Should have a primer explaining the difference and what needs to be included in objective statements. SANDAG prepared a major report where they essentially used the two term interchangeably.

VIII) Initial Announcement (Save the Date)

We invite you to participate in a workshop on:

Developing and Refining Goals & Objectives for Monitoring and Management:

Building and implementing an integrated framework for monitoring and management in San Diego County

Wednesday, November 2nd, 2011 9am-4pm
Mission Trails Regional Park

Why: **Improving the efficiency of monitoring and management in San Diego County is recognized as a high priority by SANDAG, the EMP Working Group, and the wildlife agencies. This workshop is the first in a series hosted by IEMM that will bring together stakeholders in the MSCP to build consensus and common experience in effective monitoring and management. Participation in these workshops gives you the opportunity to help drive this process.**

What: **The focus of this first workshop is to take existing guidelines and templates that have been put forward for goals and objectives and to work as a group to identify what types of goals and objectives can be linked to measurable monitoring and management activities and outcomes. As part of the workshop, we will work in small groups to develop specific goals and objectives for a range of species, communities, threats, and stressors that are relevant to San Diego County. Group topics will be narrow enough to provide the opportunity for each group to create concrete goals and objectives, but broad enough to be relevant to managers across preserves. We will be soliciting your input on the topics of these break-out groups.**

Who: **Broad participation is essential to the success of this workshop. We hope to have a diverse array of participants including land/preserve managers, resource managers, biologists, planners, rangers, regulatory agency staff, and any others involved in conservation management.**

What Next: **You will be provided more information on the workshop content and structure in the next week. To ensure that the workshop addresses your needs and interests, please take a few minutes to give us your input and help shape the content of this workshop by answering a few questions at:**

http://www.surveymonkey.com/s/5BP68MB

IX) Final Invitation

Developing and Refining Goals & Objectives for Monitoring and Management:

Wednesday, November 2nd, 2011 9am-4pm
Mission Trails Regional Park

We hope to see you there! Please RSVP by October 20th to Erin Marnocha (emarnocha@projects.sdsu.edu).

Workshop Focus:

The goal of this workshop is to provide an opportunity for local land managers to come together and discuss how to use existing guidelines to create effective goals and objectives. Although there are many published papers and technical manuals on how to develop effective goals and objectives, this continues to present some important challenges in hands-on application. After reviewing and critiquing existing goals and objectives, participants will work with colleagues to write goals and objectives for representative species and topics relevant to San Diego County. This workshop will focus primarily at the preserve level, with recognition of the importance of the broader context of regional goals and objectives currently being developed by the San Diego Monitoring and Management Program (MMP). At the outset of the workshop, MMP will provide the regional context for this workshop and discuss how the workshop complements ongoing work by MMP.

Structure:

The workshop will have three major components:

1. A plenary session in which speakers (from IEMM, MMP and from the management community) will address key issues and challenges in developing specific, measureable goals and objectives
2. Small group break-out sessions in which participants will use existing templates (e.g. SMART criteria) to develop specific goals and objectives for representative species and topics
3. Group presentations and discussion

Group Topics:

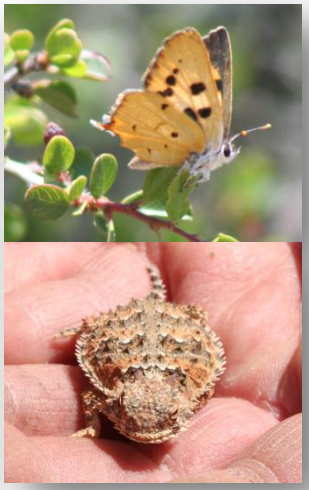
Topics are intended to be narrow enough to provide the opportunity for each group to create concrete goals and objectives, but broad enough to be relevant to managers across preserves. This list is based on feedback we've already received (to provide your feedback go to http://www.surveymonkey.com/s/5BP68MB). Groups will include:

- Rare and endemic species
- Corridors and connectivity for highly mobile wide-ranging species
- Invasive species
- Stewardship management, education and outreach

Agenda:

Time	Task
9:00 – 9:40	Welcome and general introduction
9:40-10:00	How this fits in to regional efforts (MMP)
10:00-10:45	Managers perspective
10:45 – 11:00	Break
11:00 – 12:00	Break Out Groups
12:00 – 1:00	Lunch
1:00 – 2:00	Break Out Groups
2:00 – 2:15	Break
2:15 – 3:15	Group Presentations
3:15 – 4:00	Summary and Next Steps

Please RSVP by October 20th to Erin Marnocha (emarnocha@projects.sdsu.edu).



APPENDIX 5 – LITERATURE AND DRAFT MODELS DEVELOPED FOR THE CONCEPTUAL MODELS WORKSHOP

Thread-leaved Brodiaea Conceptual Model

Narrative for: Thread-leaved Brodiaea Conceptual Model

Goals:		
Management	Persistence of existing populations of *Brodiaea filifolia* through maintenance of a robust genetic pool and preventing degradation of existing habitat	
Monitoring	Monitor the spatial extent *Brodiaea filifolia* patches (as indicated by flowering individuals) and the associated cover of non-native plants.	
Anthropogenic Threats:		
Invasive species cover	Non-native invasive forbs and grasses thought to represent a primary threat to the persistence of *Brodiaea filifolia* populations, due to direct competition and habitat alteration.	USFWS (1998, 2009, 2011) CNDDB (2012)
Human Disturbance	Human activities including trampling, mowing and discing represent direct threats, and may promote invasives. May represent a major threat to some populations	USFWS (1998, 2009, 2011) CNDDB (2012)
Altered hydrology	Both water diversion and increased urban runoff may alter the natural hydrological regime and represent a threat to *Brodiaea filifolia* populations	USFWS (1998, 2009, 2011)
Hybridization	A potentially minor threat. Thread leaved brodiaea is capable of hybridizing with congeners. Some populations in the field are through to be hybrids with *B. orcuttii.* Hybrid populations in the field have not been confirmed with genetic testing, some of these may represent undescribed species. Transplanting *B. orcuttii* to a stand of *B. filifolia* may have resulted in hybridization.	Niehaus (1971), Chester, Armstrong and Madore (2007), USFWS (1998, 2009, 2011)
Natural Drivers:		
Soil- clay content	Most *B. filifolia* populations occur in soils with high clay content, suggesting that the distribution of the species may be restricted by the distribution of appropriate soil.	USFWS (1998, 2009, 2011)
Pollination	*Brodiaea* species, including *B. filifolia* are generally self-incompatible, requiring pollination to produce seed. It is not known if self-incompatibility is complete or partial. Some genetic systems of incompatibility allow for partial self-compatibility. There is evidence that particular individuals of otherwise self-incompatible *Brodiaea* spp. and *Dichelostemma* spp. are self-fertile.	Niehouse (1971), Keator (1968), Doalson (1999)
Climate	Largely unknown. Precipitation and temperature may be correlated with patterns of flowering effort and vegetative growth, but precise climatic cues favoring these are uncertain.	USFWS (1998, 2009, 2011), CNLM unpublished data
Fire	Largely unknown, although vegetative density and number of flowering stems of other geophytes, including relatives in the same family (Themidaceae) has been noted to increase following fire.	Stone (1951), Keator (1968)

Seed dispersal	Largely unknown. Seed dispersal thought to be highly localized. Native pollinators thought to be highly localized, with some ability for bumble bees to disperse pollen longer distances. Local dispersal would influence distribution of self-incompatibility alleles.	USFWS (1998, 2009, 2011)
Herbivory	Largely unknown. Rabbits have been thought to be potentially important herbivores in some situations. In an unidentified species of *Brodiaea*, gophers were shown to reduce population density.	Fiedler and Lavin (1996), Hobbs and Mooney (1995)
Species Variables:		
Patch quality	Habitat status as influenced by anthropogenic threats and natural drivers.	USFWS (1998, 2009, 2011)
Vegetative reproduction	Vegetative reproduction may account for more than sexual reproduction, as reproduction by underground corms is high relative to documented recruitment from seed.	(Taylor, 1991), USFWS (1998, 2009, 2011)
Sexual reproduction	Relative importance of sexual reproduction in persistence of populations unknown. Presumably important for establishment of new populations, survival over long time scales (in response to changing conditions.)	Niehouse (1971), (Taylor, 1991), USFWS (1998, 2009, 2011)
Population structure	The number of populations, their size, shape and topographic distribution. Includes density and cover of each population as well as spatial characteristics. Number of corms present may be 1000 – 10,000 times greater than the number of flowering stems. Critical uncertainty are population size of corms, and the number of unique genotypes versus total number of plants in a population.	USFWS (1998, 2009, 2011), CNLM Unpublished Data
Monitoring Targets:		
Population Structure	Number of vegetative or flowering stems	
Pollinators	Presence of native pollinators	
Invasive cover	Percent cover by non-native forbs and grasses	
Patch size	Aerial extent of occupied patches	
Management Actions:		
A	Invasive removal- herbicide and mechanical	
B	Transplantation of corms to establish new populations	
C	Transplantation of corms among population to increase genetic diversity	
D	Promotion of pollinators	
E	Restricting human disturbance	
Critical Uncertainties:		
A	Actual population size of known occurrences- number of corms versus number of flowering stems, and number of genotypes.	
B	Importance of reproduction by seed	
E	Are current levels of genetic diversity limiting sexual reproduction	
E	What is the status of hybridization- is it currently occurring, does it represent a threat?	
Others:	Climate change;	

Literature Cited:

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Key Literature for: Thread-leaved Brodiaea Conceptual Model

References	Annotation
USFWS (1998, 2009, 2011) 1998- Initial listing 2009- 5 year review 2011- Critical habitat determination	A synthesis of the primary and grey literature on *Brodiaea filifolia*, including discussion of major threats to existing populations throughout the range of the species. Includes references to a large number of unpublished reports submitted to the USFWS and CDFG. Information from unpublished sources and communications includes pollinator observations, population status, and communication with taxonomic experts.
Niehaus, 1971. *A Biosystematic study of the genus Brodiaea (Amaryllidaceae). University of California Publications in Botany*	An overview of Brodiaea ecology and systematics. Includes data on interspecific crosses, selfing attempts, and basic distributional data on brodiaea taxa. Indicates that Brodiaea species are self-incompatible. Indicates that seed can be produced from interspecific crosses among a variety of brodiaea taxa.
Chester et al. 2007. *Brodiaea santarosae (Themidaceae), a new rare species from the Santa Rosa Basalt area of the Santa Ana Mountains of Southern California*	Discussion of hybridization among *Brodiaea*. Description of new species based on morphology, previously described as a hybrid of *B. orcuttii* and *B. filifolia*. Status of newly described species would benefit from molecular analysis to determine if it is a unique lineage or a product of hybridization. Currently recognized in Jepson Manual 2nd edition.

Chester, T., W. Armstrong, And K. Madore. 2007. Brodiaea santarosae (Themidaceae), a new rare species from the Santa Rosa Basalt area of the Santa Ana Mountains of Southern California. Madrono 54: 187-198.

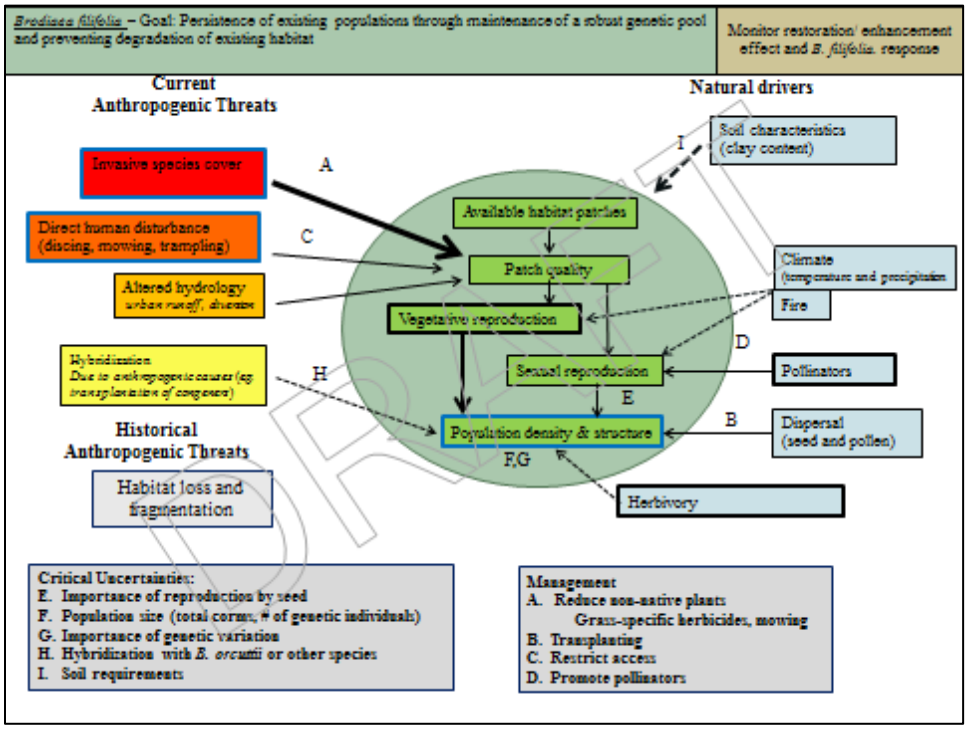
Niehaus, T. F. 1971. A Biosystematic study of the genus Brodiaea (Amaryllidaceae). University of California Publications in Botany 60.

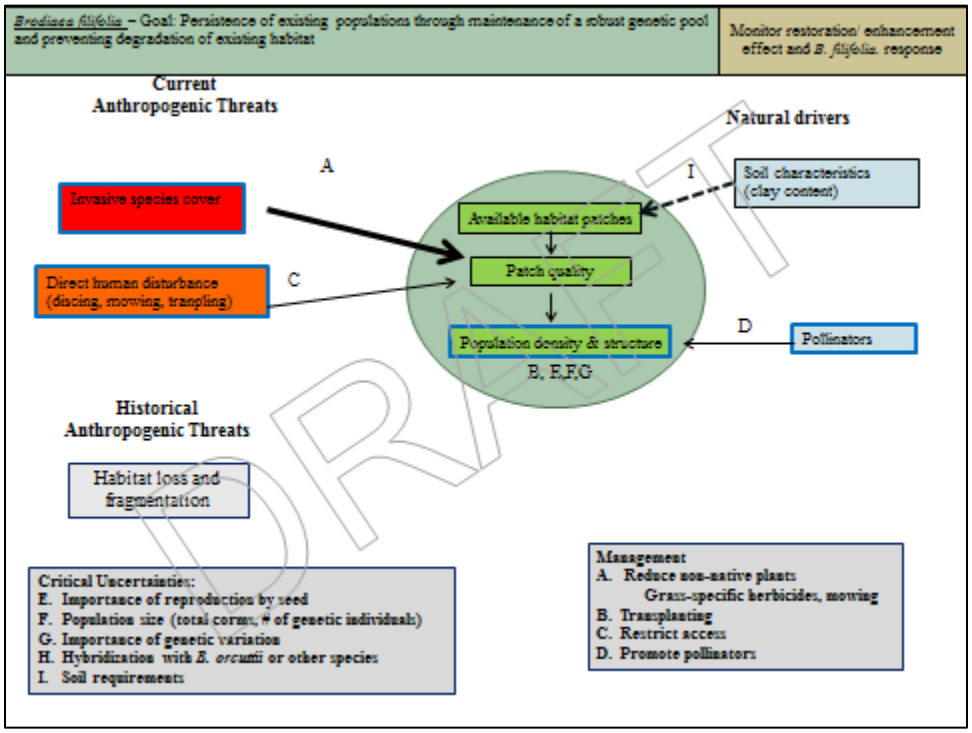
U.S. Fish and Wildlife Service. 1998. Endangered and threatened wildlife and plants; determination of endangered or threatened status for four southwestern California plants from vernal wetlands and clay soils. Federal Register 63:54975-54994.

U.S. Fish and Wildlife Service. 2009. *Brodiaea filifolia* (thread-leaved brodiaea); 5-Year Review: Summary and Evaluation. U.S. Fish and Wildlife Service, Carlsbad Fish and Wildlife Office, Carlsbad, California August 13, 2009.

U.S. Fish and Wildlife Service. 2011. Endangered and threatened wildlife and plants;. Final Revised CriticalHabitat for Brodiaea filifolia (Thread-Leaved Brodiaea) Federal Register 76:6848-6925.

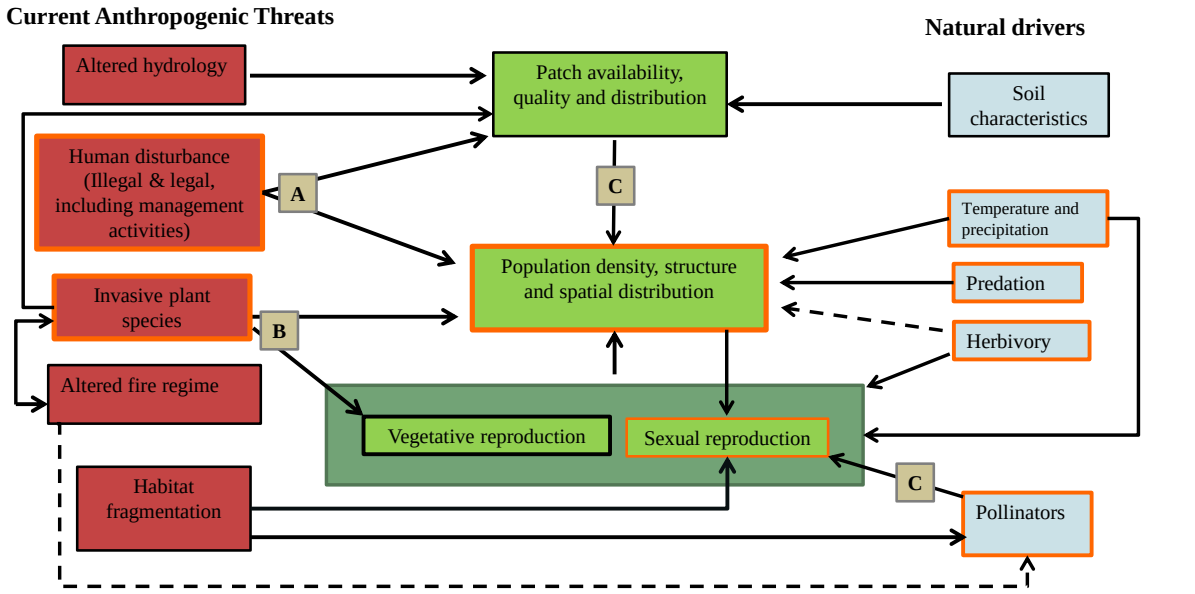
Draft Models for: Thread-leaved Brodiaea Conceptual Model





Final Model *for: Thread-leaved Brodiaea Conceptual Model*

Brodiaea filifolia – Goal: Persistence of existing populations through maintenance of a robust genetic pool and preventing degradation of existing habitat



Critical Uncertainties:
1. **Apparent vs. actual population size**
2. **Importance of sexual reproduction**
3. **Gene flow / genetic diversity**
4. **Pollination- host specific vs. generalist pollinators**
5. **Hybridization**
6. **Defining habitat**
7. **Correlations between climate and pop. dynamics**

Management
- **A. Restrict human access**
- **B. Invasive species control**
- **C. Restoration of plants and pollinators**

Monitoring
1) **Population distribution & size**
2) **Invasive presence and cover**
3) **Qualitative survey for disturbance, herbivory, & other threats.**

California Least Tern Conceptual Model

Narrative for: California Least Tern Conceptual Model

Goals:		
Management	Achieve recovery criteria identified in the CLT recovery plan • At least 1,200 breeding pairs in at least 20 of 23 management areas • Each management area must have at least 20 breeding pairs • Each management area must have a 3-year mean reproductive rate of at least 1.0 young fledged per breeding pair	
Monitoring	Continue to monitor number of breeding adults and fledgling success at all colonies annually and measure responses in these variables to management actions	
Anthropogenic Threats:		
Human Disturbance	• Direct: colony visits, watercraft • Indirect: dogs, increased predator presence • Thought to be the primary culprits in the initial decline of CLT • Management improvements (i.e., fencing, signage, etc.) have helped • Enforcement issues remain a problem in certain areas	Chambers 1908; Edwards 1918; Massey 1974; Atwood et al. 1977; Fancher 1992; USFWS 5-year review 1996
Commercial & Recreational Fishing	•Impact generally not well understood •Cury et al. (2011) - 1/3 of the maximum prey biomass (small fish and krill) needed to prevent reduced and more variable productivity in seabirds. Not clear where current prey abundance is in relation to this threshold •Competition with commercial/recreational fisheries could be problematic	Cury et al. 2011
Pollutants	•Contaminant studies of CLT have found moderate concentrations of mercury, selenium, organochlorines but these were lower relative to other seabirds •Zeeman et al. (2008) found organochlorine levels (DDT, PCBs, etc.) to be lower than studies from the 1980s and 1990s •Threshold levels thought to impact behavior and reproductive success are still uncertain and not well understood •Periodic monitoring of contaminant levels in blood/eggs likely is warranted	Boardman 1988; Collins 1992; Hothem and Zador 1995; Hothem and Powell 2000; Zeeman et al. 2008
Natural Drivers:		
Nesting Habitat	•Site fidelity of CLT is generally high though variable (43-78% in LA County) •Movement between colonies is rare, and generally < 15km •CLT can successfully nest in highly disturbed areas (airports, active beaches) on a variety of substrates (rooftops, dredge spoil) •Second-wave nesters tend to be 2yo nesting for the first time or older re-nesters who experienced nest failures •A 3-year study at Venice Beach found that terns preferred and were more successful in areas with < 30% veg cover	Altman and Gano 1984; Atwood and Massey 1988; Massey and Atwood 1981; Ryan et al. 2010

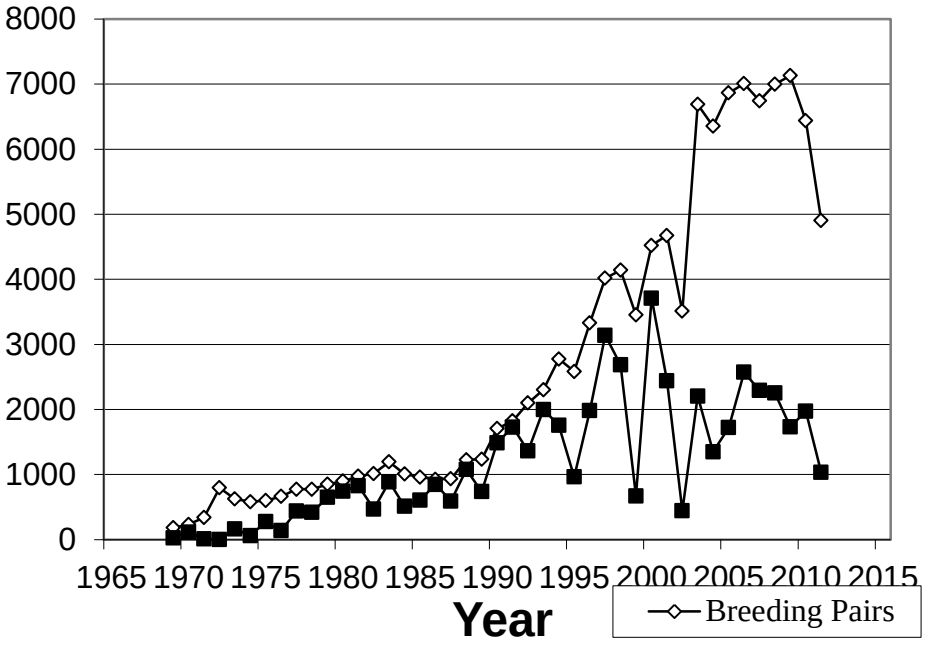
Predation	•Predation accounted for ~27% of total mortality of CLT in 2010 •American crows, gull-billed terns, common ravens and coyotes account for most predation on CLT •Akcakaya et al showed that simulated reduction of predation improved population viability only when vital rates (survival and fecundity) were low •Economic analysis of predator removal efforts showed an 8.1% increase in productivity for a 25% increase in funding, and an investment of >$1.04 million over 7 years led to roughly a tripling of nesting pairs	Annual Reports; Akcakaya et al. 2003; Shwiff et al. 2005
Food Availability	•Generally not well understood, though studies are in progress to better understand tern foraging and diet (e.g., Robinette et al.) •Previous studies have shown that anchovies and topsmelt are important components of CLT diets •Decreased availability of forage fish may be negatively impacting reproductive success (**see graph in literature table**). This may be the result of changes in productivity in coastal zone •CLT generally forage in shallow waters < 2mi offshore	Atwood and Minsky 1983; Atwood and Kelly 1984; Birkhead 1985 (book); Keane 2004
Climate	•Influence largely unknown •Extreme precipitation and weather events can lead to nest failure •Larger-scale processes are impacting ocean productivity and subsequently CLT food availability •Sea level rise due to climate change will impact CLT populations as well	Chavez et al. 2003; Cury et al. 2011
Species Variables:		
Reproduction	• Although breeding pairs have increased 578% from 1988-2009, productivity has declined inconsistently, ranging from ~0.23-0.95 fledglings/pair statewide (**see graphs in literature table**) • Understanding of factors driving reproductive success is critical for management and conservation of CLT • Need robust methods to estimate fledgling success, number of nests, etc. • Lack (1968) suggests that low breeding success in any given year many not endanger populations of long-lived species • Akcakaya model illustrates sensitivity of the model to vital rate parameters indicating they are critical uncertainties that need to be addressed	Annual Reports; Lack 1968 (book); Akcakaya et al. 2003; Massey 1989; Bailey and Servello 2008; Schuetz 2011
Survival	• Massey et al. estimated age-specific survival rates for CLT at Venice Beach (0.16 hatch, 0.81-0.92 adult), but productivity was significantly higher than the rest of the state population • Collins et al. estimated similar rates, though sample size and resighting rates were problematic • Further banding studies are necessary to obtain accurate estimates of age structure and survival rates for CLT throughout their range • Akcakaya model illustrates sensitivity of the model to vital rate parameters indicating they are critical uncertainties that need to be addressed	Massey et al. 1992; Collins et al. 1998; Akcakaya et al. 2003; Bailey and Servello 2008

Movement	• Burger et al. estimated turnover rates between 0.16-0.30, suggesting CLT do not move long distances and generally exhibit high site fidelity • Collins et al. (1998) found CLT from Camp Pendleton in Huntington Beach and Batiquitos Lagoon • Further study is necessary to determine movement rates and population structure through CLT range	Burger 1984; Collins et al. 1998; Patton et al. (ongoing); others?

Key Literature for: California Least Tern Conceptual Model

References	Annotation
Akcakaya et al. 2003. *Metapopulation dynamics of the CA least tern*	Metapopulation model included age-structure, annual variation in survival and fecundity, and regional (ENSO) and local (predation) catastrophes. Model predicted low risk of substantial decline over 50 years. Recommended replicating Massey et al. (1992) study to get better vital rate estimates.
Bailey and Servello 2008. *Chick survival, fledgling residency and evaluation of methods for estimating fledgling success in least terns*	Authors banded chicks to better understand chick survival and fledgling residency time. 21-d chick survival rates ranged from 0.14 to 0.74. Dugger (2000) reported chick survival of 0.43 to 0.62. Fledgling residence time (days on colony after initial fledge) ranged from 15-30 days.
Burger 1984. *Colony stability in least terns*	Annual turnover rates varied from 0.16-0.30 (mean = 0.22; SD = 0.05), which is low to intermediate compared to other coastal nesting seabirds. Turnover was calculated by site, not individuals (colony color band, not ind ID bands).
Collins et al. 1998. *Banding of adult CLT at MCB Camp Pendleton between 1987-1997*	Resighting rates were not necessarily reflective of actual adult return rates but of search efficiency. Resighting at other colonies was likely underreported due to lower effort in other areas. Pendleton birds were found in Huntington Beach and Bataquitos Lagoon. Most valuable observations were seen before and after nesting season, not during. Mean mate retention was ~54% and adult survival ranged from 0.76-0.93.
Danhardt and Becker 2011. *Herring and sprat abundance indices predict chick growth and reproductive performance of common terns breeding in the Wadden Sea*	North Sea herring recruitment and sprat abundance in the Wadden Sea explained the largest part of common tern breeding success from 1981-2009.
Elliot et al. 2007. *Breeding biology and status of the CLT at Alameda Point, SFB, CA*	Found that breeding success declined from the mid-1990s to 2004, similar to statewide and regional (N&S) trends (Yu 2009; **see graphs**). Also studied diet by observing fish dropped at the colony and found that breeding success was significantly and positively correlated (r = 0.55) with proportion of anchovy dropped.
Keane 2006. *Experiment to protect least terns during an oil spill at the Port of LA nesting area*	Author tested whether or not terns would use stocked backyard pools as alternate foraging sources in the case of preferred foraging grounds being contaminated. They found that some CLT were able to successfully obtain fish from pools, and larger, murkier (algae filled) pools were preferred.
Marschalek 2011. *CLT breeding survey 2010 season*	An alternate index of population size (max number of active nests) and a new fledgling estimator (total chicks – dead chicks) were discussed. Both seem to map similarly to current indices used.
Massey et al. 1992. *Demography of a CLT colony including effects of the 1982-1983 El Nino*	Return rate of banded hatchlings, young breeders, and older breeders was 0.16, 0.81, and 0.92, resp. and much lower in ENSO years (0.03-0.82). Lifetime productivity was estimated to be 1.49 with a breeding life of 9.63 years. Productivity at Venice colony was significantly higher than the rest of the state (> 1.0 fl/pr in all but 2 years vs. never > 0.9 in the rest of the state), suggesting results may not be applicable to entire population. Age profile of CLT showed that peak breeding age was 3 years and 80% of birds were 2-7.

References	Annotation
Ryan et al. 2010. *Venice Beach least tern colony habitat improvement and restoration study 2006-2009*	Authors created a 20x20m grid across the colony and used 3 treatments: 1) no manipulation, 2) less than 30% veg cover, and 3) removal of all veg to at least 5% cover. Authors found that nests were less likely to succeed if they were placed within 20 m of the enclosure fence, in grids with fewer than 5 other nests (<125 nests/ha), more than 5 m from their nearest neighbor and more than 70 m from the center of the colony. Additionally, terns were more likely to be predated in areas with less than 5% vegetation cover, and prefer to nest, and are most successful, in areas with 20-40% vegetation cover. They found that the best vegetation management technique was to reduce vegetation to less than 30% cover, but even this was not as successful as areas that are naturally between 5-30% vegetation cover.
Scheutz 2011. *Reproductive declines in an endangered seabird: cause for concern or signs of conservation success?*	Though breeding pairs increased substantially from 1988-2009, both clutch size and productivity declined. Other than latitude, site characteristics had little bearing on either clutch size or reptoduction. Causes of variation remain poorly understood and may reflect 1) reduced food availability, 2) increased density-dependent competition, or 3) age-dependent reproduction reflective of a young population.
Shwiff et al. 2005. *Ex post economic analysis of reproduction monitoring and predator removal variables associated with protection of CLT*	Predator removal and monitoring hours showed significant impacts on adults and fledglings, though predator removal efforts showed a negative relationship with predator removal (suggesting they are hard to protect from predators). A 25% increase in funding yields an 8.1% increase in productivity, or an investment of >$1.04 million over 7 years led to roughly a tripling of nesting pairs.
USFWS 2006. *CLT 5-year review*	Gross number of pairs is nearly 6 times the recovery goal, but no other goal had been met. Thirty of 40 known nesting sites in CA have more than 20 breeding pairs, and numbers are not uniformly distributed across sites. Reproductive rates have been considerably lower than those recommended (0.23-0.36), which suggests recovery goal of 1.0 fl/pr is not necessary. Recommended revisiting and revising recovery plan and continuing current monitoring and management programs.
Zeeman et al. 2008. *Characterizing exposure and potential impacts of contaminants on seabirds nesting at SSDB*	Results of eggshell analyses indicate that eggshell thicknesses for failed eggs of black skimmer, Caspian terns, elegant terns, and perhaps California least terns, collected in 2005, were lower than normal, as compared with thicknesses measured in eggs collected before 1945. Concentrations of organochlorines (DDT, DDE, etc.) were lower in least tern eggs compared with concentrations observed in the 1980s and 1990s. Although numerous elements were detected in seabird eggs and forage fish, none were present in eggs at concentrations of concern.



Summary of breeding pairs and fledglings from 1968-2011 (Marschalek, unpublished)

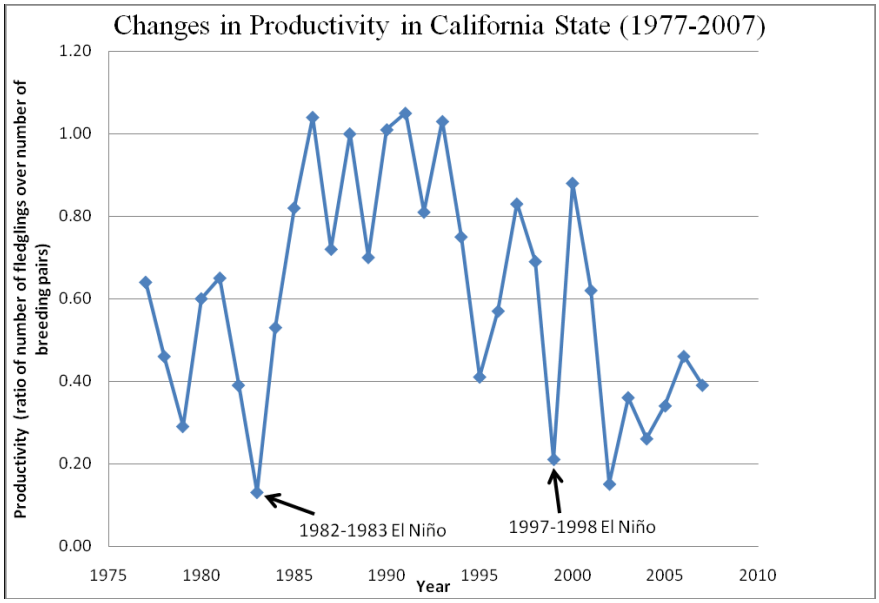


Figure 18 (Lu 2009). CLT productivity at all sites in CA from 1977-2007 with corresponding El Nino events

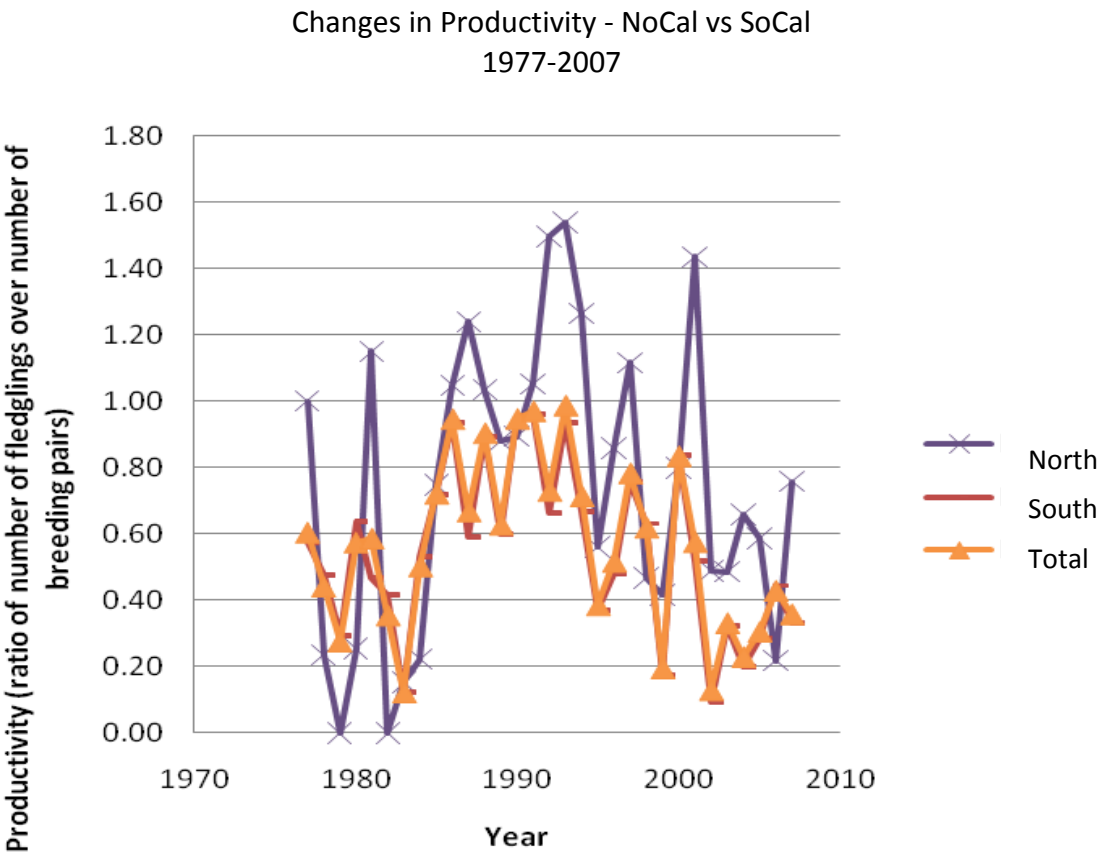


Figure 6 (Lu 2009). CLT productivity in northern vs. southern CA

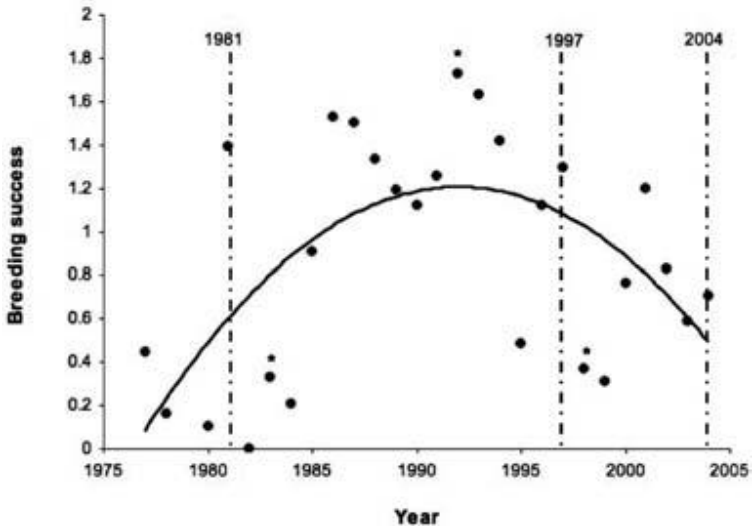


Figure 3. (Elliot et al 2007). Breeding success (fledglings / breeding pair) of the Alameda Point Least Tern colony from 1976- 2004. (* = El Niño years. Years of important site changes are noted: 1981 = electric fence was erected; 1997 = Naval Air Station closure; 2004 = chain link fence erected.)

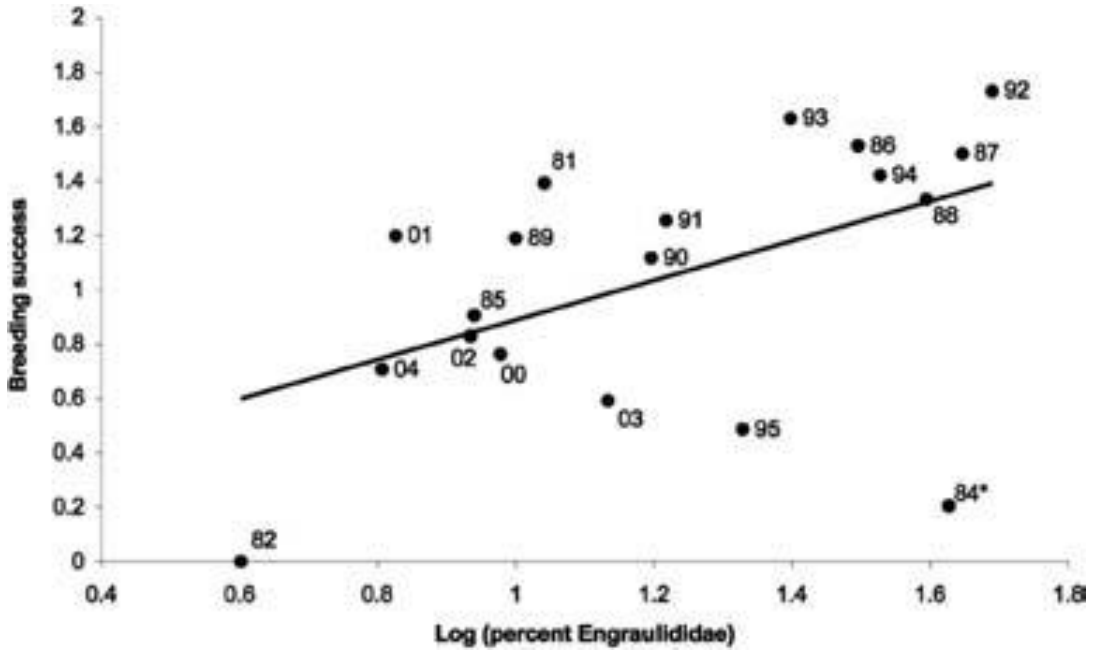
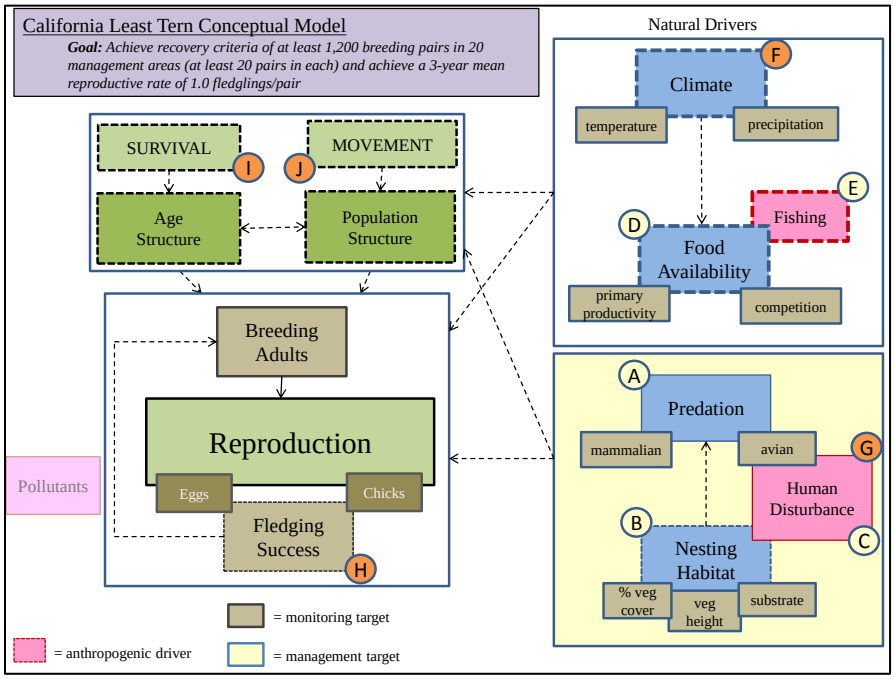
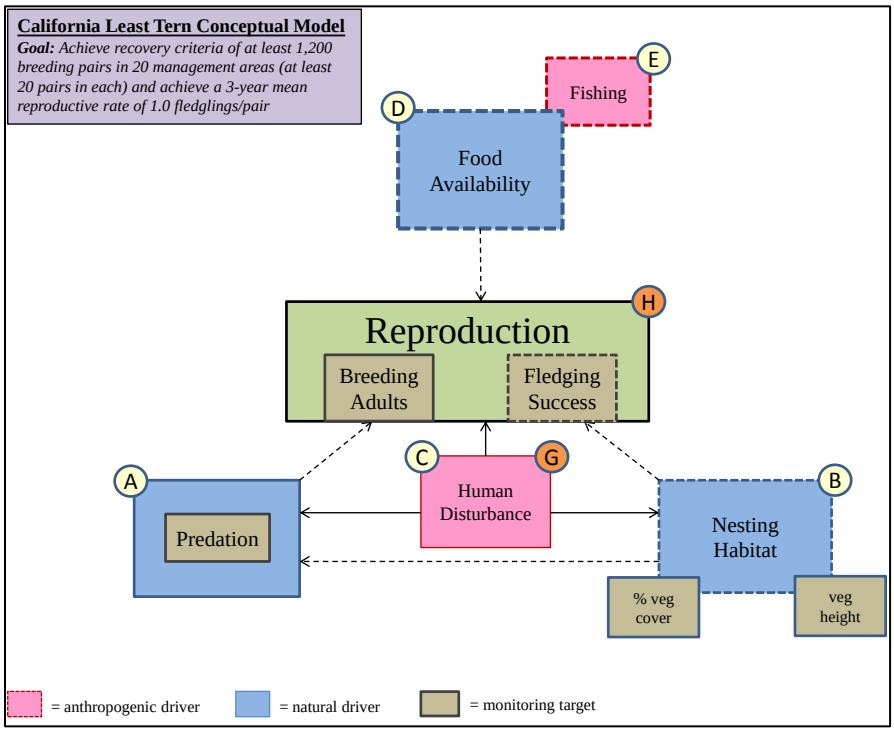


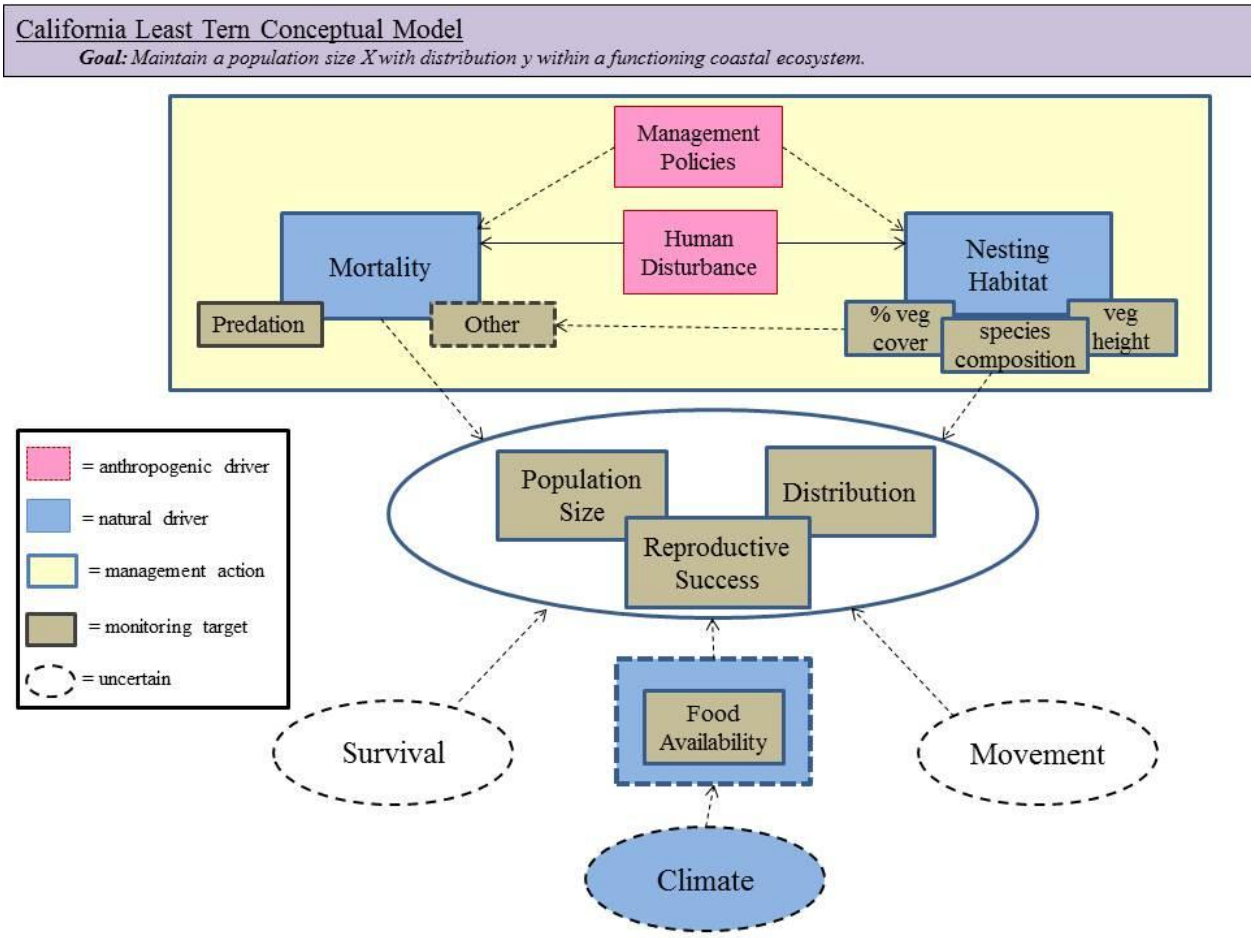
Figure 6.(Elliot et al. 2007) Least Tern breeding success and the percentage of Engraulididae in the dropped prey. (Each point is labeled with the two-digit year. * = possible outlier.)

Draft Models for: California Least Tern Conceptual Model

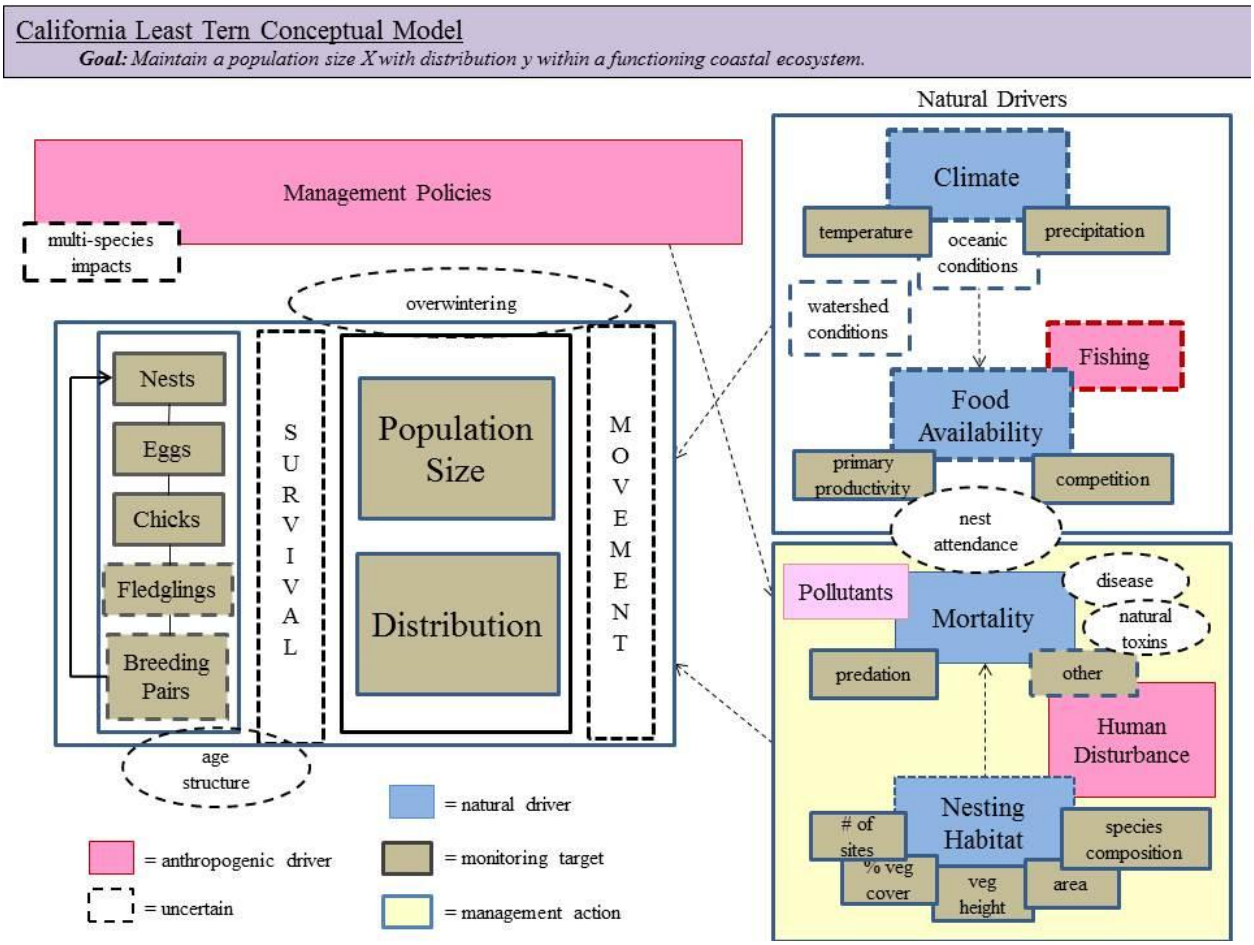




Final Model #1 *for: California Least Tern Conceptual Model (**preferred model**)*



Final Model #2 *for: California Least Tern Conceptual Model*



Hermes copper Conceptual Model

Narrative for: Hermes copper Conceptual Model

Goals:		
Management	To preserve Hermes copper populations at currently occupied sites, and to research critical uncertainties key to management.	
Monitoring	To monitor long-term site occupancy, discover new populations in San Diego County, and to resolve questions relevant to management options, including a fire response plan, in vitro rearing techniques and possible reintroduction of individuals to previously occupied sites extirpated by fire.	
Anthropogenic Threats:		
Fire	Wild fires cause direct mortality of Hermes copper. Frequent "megafires" (fires of unusually large extent) are especially problematic due to Hermes copper dispersal limitation and the low rate at which the species recolonizes areas.	USFWS, 2011, Marschalek and Klein, 2010
Development	A large number of historical Hermes copper population centers are now developed, diminishing available habitat and increasing fragmentation.	USFWS, 2011
Fragmentation	Male Hermes copper do not disperse long distances, and generally do not cross large patches of unsuitable habitat. Although females may have the capacity for long distance dispersal, habitat fragmentation (including that caused by type conversion of shrub lands into grasslands) may exacerbate problems associated with dispersal limited species.	Marschalek and Klein, 2010; Marschalek and Deutschman, 2008; Deutschman et al. 2010;
Road Kill	It is unclear if road kill is a substantial issue for Hermes copper. Given their short dispersal distances and relatively low-flying habit it could potentially be a problem. Marschalek has observed at least one individual that appeared to have been killed in a collision; however the relative importance of this threat is unknown and at this time seems to be far less important than that of fire. This threat may be better addressed as an uncertainty.	Marschalek and Klein 2010

Natural Drivers:		
Vegetation Community	Hermes occur in coastal sage scrub and southern mixed chaparral. Hermes copper utilize spiny redberry (*Rhamnus crocea*) as a host plant for eggs, larvae and pupation. Adult Hermes copper show a strong preference for nectaring on CA. Buckwheat (*Eriogonum fasciculatum*), however may utilize other plants occasionally, including chamise (*Adenostoma fasciculatum*) and tarplants (*Deinandra sp.*).	Marschalek and Deutschman, 2009; Marschalek and Deutschman, 2008; Klein Pers.Com.; USFWS, 2011; Thorne, 1963; Marschalek pers. obs.
Species Range	Although the appropriate vegetation communities extend as far north as San Francisco, Hermes copper has never been documented north of San Diego county. The species also occurs in northern Baja California; however the status of these populations is unknown. They have never been reported along the coast, having occurred as far west as the community of Kearny Mesa, and have not been reported east of the community of Pine Valley.	Marschalek and Klein, 2010; Thorne 1963; USFWS 2011
Predators	It is unclear if predators or parasitoids on adult butterflies play a significant role in Hermes copper dynamics. A single observation of a jumping spider feeding on an adult was made by Marschalek in 2010. Other potential predators or parasitoids are unknown.	Marschalek pers. com.
Temperature	The timing of emergence and the single annual flight season of Hermes copper appears to be influenced by weather conditions and elevation, although the specifics of this relationship are as yet unknown. In addition, activity on a given day in the flight season is strongly influenced by temperature and cloud cover, with Hermes copper remaining inactive and generally unseen until a temperature of 72 degrees F. Furthermore, Hermes copper tend to prefer the north and west sides of roads and trails for what seem to be purposes of thermoregulation.	Marschalek and Deutschman, 2008, Marschalek and Klein, 2010, Deutschman et al., 2010, USFWS, 2011
Species Variables:		
Population Structure	Genetic analysis indicates that Hermes copper dispersal is complex. While individuals sampled near one another may be unrelated, suggesting that small scale landscape barriers play a role in the population structure, individuals at two different sites may be genetically similar suggesting that occasional long-distance dispersal is possible under the right conditions. At this time genetic analysis suggests that the largest population centers in the south-eastern part of the county may be mixing at higher rates, but that there is differentiation from this area and populations located at more northerly portions of the county.	Deutschman et al. 2010, Deutschman et al. 2011

Male Behavior	Male Hermes copper are highly territorial, patrolling breaks in the shrub canopy and often returning to the same perch after being disturbed. They show a strong preference for breaks or edges of the shrub canopy, including those along roads and trails, but generally do not cross long patches of unsuitable habitat. Due to the difficulty of catching and re-sighting females, most non-genetic work on dispersal has been done on males, who have short maximum dispersal ranges (generally under 200m).	Marschalek and Deutschman 2008; Marschalek and Klein 2010
Female Behavior	Female Hermes copper may be found in the same open spaces occupied by males, however, upon flushing they fly quickly away into the brush and do not generally return. Based on genetic information some long distance dispersal events do occur, however field studies suggest that male Hermes copper typically do not exhibit such movements. Given that other *Lycaena* show different behavior between the sexes it seems probable that females disperse longer distances than males.	Deutschman et al., 2010; USFWS 2011
Reproduction	Most of the Hermes copper life cycle is achieved on spiny redberry, including egg-laying, larval feeding, and pupation. Eggs are approximately 0.5mm in diameter, generally laid on the underside of relatively new growth, often near an intersection with another branch or leaf. Sources and rates of mortality for non-adults are unknown.	Thorne 1963; Marschalek and Deutschman, 2009
Dispersal	Male Hermes copper appear to be extremely dispersal limited. Evidence suggests that some long-distance dispersal may occur within the core population centers in the south-east of San Diego County, but that more northern populations are relatively disconnected. Long-distance dispersal seems to be attributable to females.	Marschalek and Deutschman 2008; Marschalek and Klein 2010; Deutschman et al., 2010m Deutschman et al. 2011; USFWS 2011
Monitoring / Research Targets:		
Adult Male Population	The adult male abundance can be used to identify new population centers and the relative size of that population. Larger populations tend to be robust, occurring at the same sites year after year, and may not need to be monitored frequently once presence is established. Smaller populations should be monitored yearly until it is determined if they are stable or not.	
Female Behavior	Female behavior is a key uncertainty and needs more research. Female behavior could potentially hold the key to making determinations about what constitutes connected populations, and high habitat quality.	
Reproduction/ Ovaposition	Where females choose to oviposition eggs could be crucial to identifying what constitutes high quality habitat. This information could be used to determine if unoccupied sites with redberry are simply unoccupied, or if there is some crucial factor that makes them unsuitable. In addition reproductive success is the crux of maintaining the species, and it is unclear if eggs are subject to predation or other stressors.	
Larval Biology	Very little is known about the biology of Hermes copper larvae. This stage could be sensitive to a number of environmental stressors, predation and parasitism. In addition the transition from egg to larvae appears to be the stage that limits our ability to culture Hermes copper in a laboratory setting.	

Critical Uncertainties:	
A	Differential habitat use and dispersal by males and females, as it pertains to reproduction and connectivity
B	The relative importance of Allee effects, isolation, genetic bottleneck, and genetic pollution as they pertain to species vigor, the need for connectivity and reintroduction
C	Larval biology, secondary diapause and parasitoids: Very little is known about larval biology and behavior. We have no information on if this species can undergo a secondary diapause, but given wild annual fluctuations in adult population size it seems possible. In addition because larvae can be difficult to find we have no information on potential parasitoids of Hermes copper or rates of parasitism which can be substantial in other *Lycaena* species
D	Small Scale Disturbance: do trails, dirt roads, and other disturbances associated with human recreational and other use impact Hermes copper habitat choices or behavior, especially surrounding reproduction?
E	Vegetation community structure: in areas with redberry, what determines when and where Hermes copper will occur? Are all stands of CSS or chaparral with redberry potential habitat that is unoccupied, or are other factors at work?
F	Climatic Conditions: spring rainfall, temperature regimes and other factors that could be affected by climate change.
Management Actions:	
G	Fire suppression, fuel manipulation or other measures to protect redberry stands from fire in the short term.
H	Reintroduction to previously occupied sites extirpated by fire
I	In vitro rearing/ farming of Hermes copper for release and preservation of genetic diversity
J	Enforcement of poaching regulations: Specimens of Hermes copper butterfly have been for sale on-line previously, but have not appeared since 2004 (USFWS, 2011). Collection does not, therefore seem to be a threat to the species, however this should be monitored and followed up on periodically.

Key Literature for: Hermes copper Conceptual Model

References	Annotation
United States Fish and Wildlife Service 2011 *Endangered and threatened wildlife and plants; 12-month finding on a petition to list Hermes copper butterfly as endangered or threatened* The Federal Register 50 CFR(17): 20918-20939. http://federalregister.gov/a/2011-9028	• Hermes copper added to the candidate species list for the Federal Lists of Threatened and Endangered Wildlife and Plants. • Hermes copper has been **extirpated at more sites than it is currently found**. As of 2011, of the 57 known historical populations, 17 populations are extant, 28 populations are believed to have been extirpated, and 12 populations are of unknown status. • Identifies the primary threats to Hermes copper as development, fire, and habitat fragmentation
Marschalek and Klein 2010 *Distribution, ecology, and conservation of Hermes copper (Lycaenidae:* Lycaena [Hermelycaena] hermes) Journal of Insect Conservation 14:721-730	• **Male dispersal is very limited** • **Wildfires in 2003 and 2007 extirpated many populations and is a major threat to the species' survival** • Current distribution is reduced from historic ranges, specifically in extreme southern and northern San Diego County • Results underscore need to better understand habitat requirements and connectivity of populations
Deutschman et al 2011 *Two-year evaluation of Hermes copper* (Lycaena hermes) *on conserved lands in San Diego County* SANDAG Final Report MOU # 5001442.	• In 139 site visits during the six week flight season, a total of 252 adults were counted across 14 occupied sites. Of those 14 sites, only five sites were occupied by relatively large populations. • The populations are relatively stable through time, although numbers may vary dramatically based on temporal influences, such as rainfall and temperature. The fate of smaller populations is unclear and should be studied. • Used AFLP markers to examine genetic differentiation (and dispersal). **Occupied patches of redberry in the eastern part of the range are relatively well connected by dispersal. Movement is restricted in parts of the landscape, particularly along the edges of the species distribution.** • Provides a conceptual model for the species

Marschalek and Deutschman 2008 *Hermes copper (*Lycaena [Hermelycaena] hermes: *Lycaenidae): life history and population estimation of a rate butterfly* Journal of Insect Conservation 12:97-105	• Description of **life history traits**, including temperature thresholds, timing of flight season, and habitat preferences, such as preference for openings in habitat like those created by trails and roads • Within suitable habitat, California buckwheat was the strongest predictor of the presence of Hermes Copper. Adults used California buckwheat almost exclusively as nectaring source. • Densities and flight season varied greatly among sites • Evaluated 3 methods for indirect population size estimate. In absence of mark-release-recapture estimate, population sizes need to be estimated from observational data, like standardized Pollard Walk surveys.
Thorne 1963 *The distribution of an endemic butterfly Lycaena hermes* Journal of Research on the Lepidoptera 2(2): 143-150	• The initial description of Hermes copper biology and life history • Identified the species range as • Describes **vegetation associations**. Hermes copper uses spiny redberry as larval host and California buckwheat as nectar source.

Additional Literature

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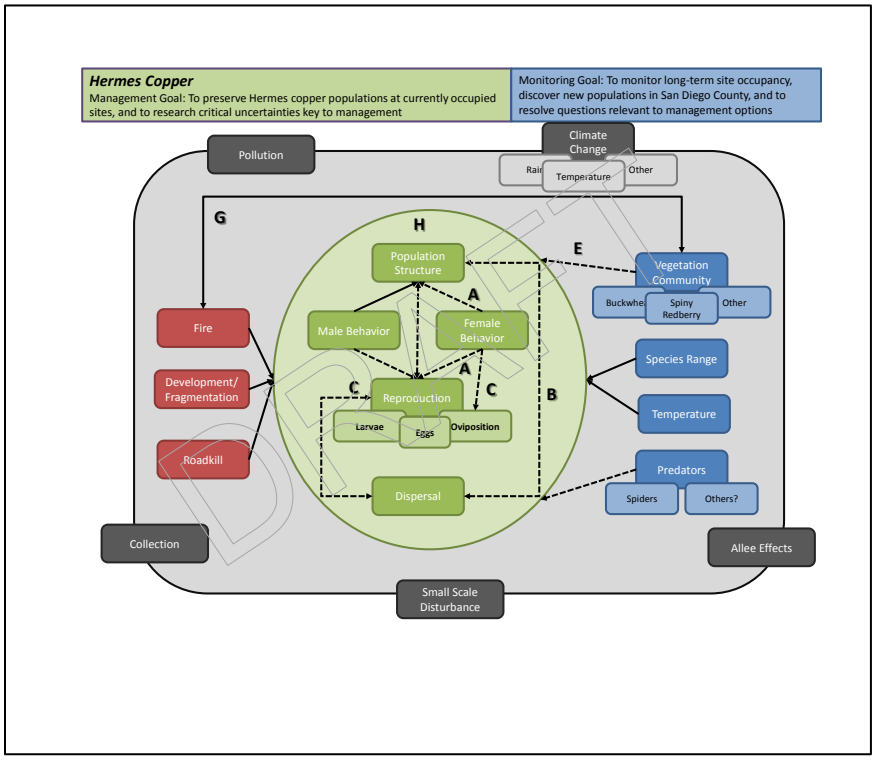
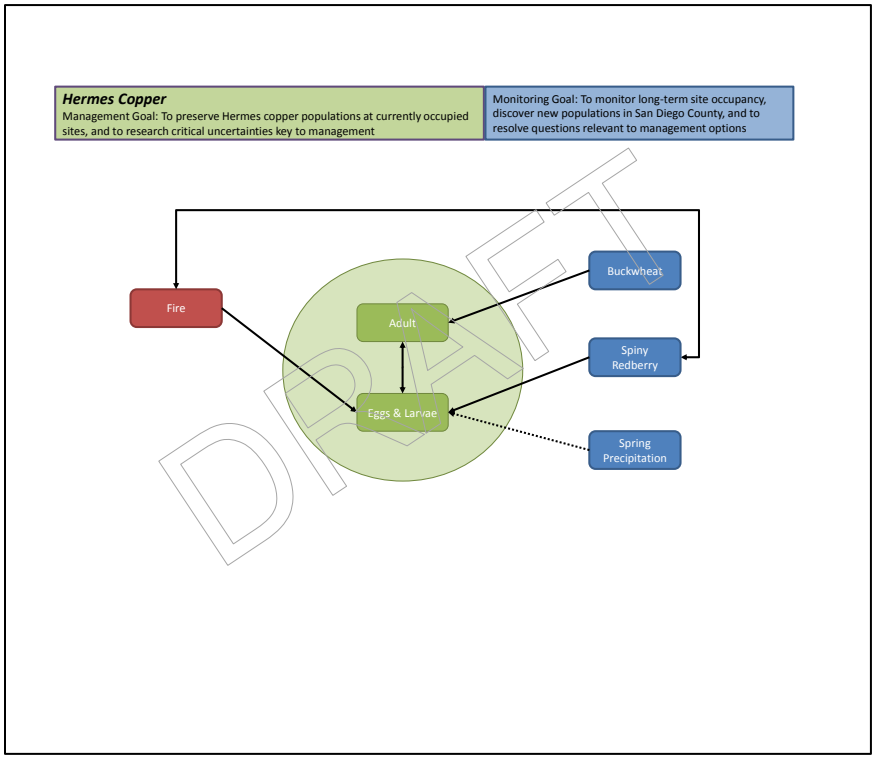
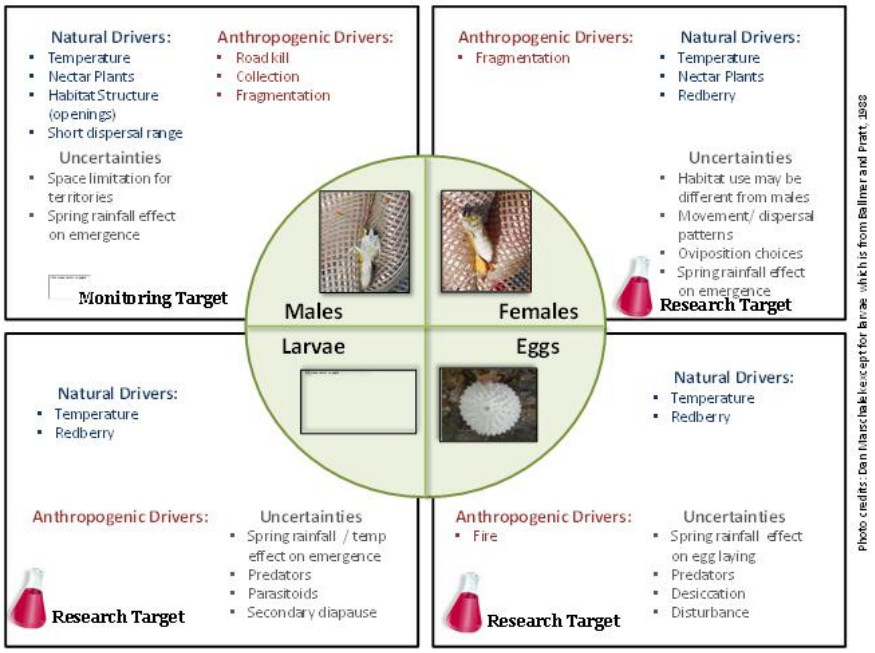
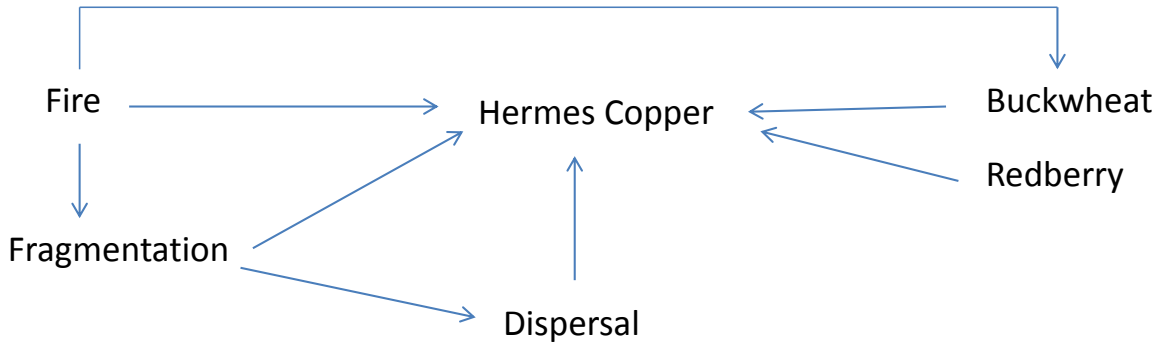
Draft Models for: Hermes copper Conceptual Model



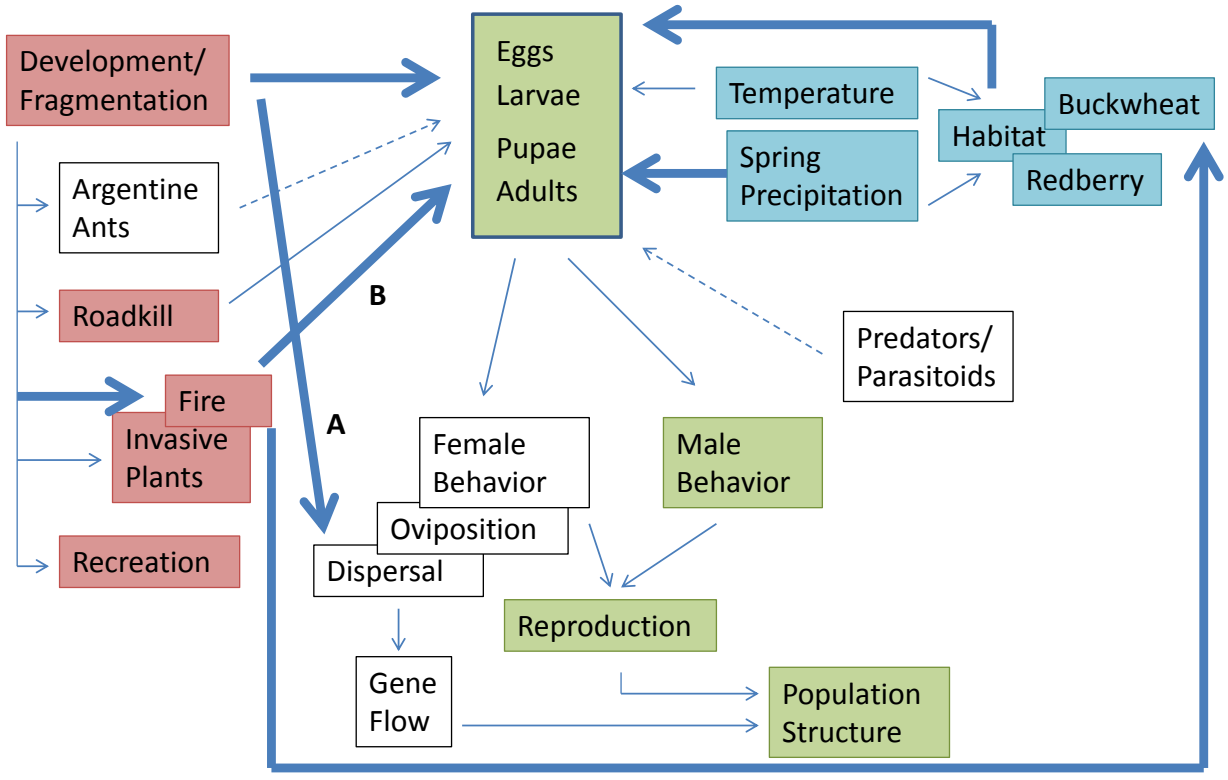



Natural Drivers:
Temperature
Nectar Plants
Habitat Structure (openings)
Short dispersal range
Anthropogenic Drivers:
Road kill
Collection
Fragmentation
Uncertainties
Space limitation for territories
Spring rainfall effect on emergence
Monitoring Target
Anthropogenic Drivers:
Fragmentation
Natural Drivers:
Temperature
Nectar Plants
Redberry
Uncertainties
Habitat use may be different from males
Movement/ dispersal patterns
Oviposition choices
Spring rainfall effect on emergence
Research Target
Males
Females
Larvae
Eggs
Natural Drivers:
Temperature
Redberry
Anthropogenic Drivers:
Uncertainties
Spring rainfall / temp effect on emergence
Predators
Parasitoids
Secondary diapause
Research Target
Natural Drivers:
Temperature
Redberry
Anthropogenic Drivers:
Fire
Uncertainties
Spring rainfall effect on egg laying
Predators
Desiccation
Disturbance
Research Target
Photo credits: Dan Mascitelli except for larvae which is from Ballmer and Pratt, 1988

***Final Model #1** for: Hermes copper Conceptual Model*



***Final Model #2** for: Hermes copper Conceptual Model*



CSS Conceptual Model

Narrative for: CSS Conceptual Model

Goals:		
Management	Maintain dynamic community structure and composition to promote animal, plant and ecosystem function	
Monitoring	Monitor the extent and status of CSS within Western San Diego County	
Anthropogenic Threats:		
Fire management	Fire practices such as fire suppression, fuel breaking and prescribed fire that influence fire frequency, severity and size, as well as plant and animal CSS structure. High fire frequency is thought to favor non-native grasses over native shrubs. In addition there appears to be a feedback loop between the flashy fuels created by non-native grasses and fire which contributes to a shortened fire return interval.	(Schwilk and Jon, 1998; Keeley, 2002; Wells et al., 2004; Keeley, Baer-Keeley, and Fotheringham, 2005; Syphard et al., 2007; Talluto and Suding, 2008; D'Antionio and Vitousek, 1994)
Human ignition sources	A primary cause of increased fire frequency, strongly associated with urbanization, fragmentation and the expansion of the Wildland Urban Interface (WUI). Most human ignitions are associated with direct disturbances by humans including, but not limited to, recreation, roads, maintenance and utilities.	(Keeley, 2002; Wells et al., 2004; Keeley, Baer-Keeley, and Fotheringham, 2005; Syphard et al., 2007)
Direct disturbance and edge effects	Direct disturbance, such as illegal trail creation, that impacts CSS on a small scale, but which can potentially become wide-spread if left unchecked. Edge effects also include animals and plants commensal with humans, which spread into undisturbed habitat from the point of introduction. Increased predation from human-promoted predators, both wild-meso predators and domesticated pets adds additional pressure at the urban edge.	(Zink et al., 1995; Crooks and Soule 1999;Holway, 2005; Cox and Allen, 2008; Fleming, Diffendorfer, and Zedler, 2009)
Non-native plants	Non-native plants reduce shrub recruitment, drive conversion to grassland, may promote increased fire frequency, and seem to compete with native forbs for room in the plant interspaces characteristic of CSS. Plants were introduced through a variety of vectors, including grazing, intentional introduction for fodder, accidental release and horticulture. Although some larger non-native plants are frequently eradicated as part of restoration efforts, non-native grasses and forbs tend to be considered a permanent, if not manageable problem.	(Eliason and Allen, 1997; Lambrinos, 2000; Sax, 2002; Beyers, 2004; Cox and Allen, 2008; Fleming, Diffendorfer, and Zedler, 2009, D'Antionio and Vitousek, 1994)
Habitat fragmentation	An ongoing threat to coastal sage scrub- directly and indirectly (through isolation of patches and reduction of patch size) reduces plant and animal diversity. Fragmentation impedes habitat connectivity necessary to support animal species which require large home ranges, and proves a significant barrier for plants and other species which require a large degree of genetic mixing to remain viable.. Fragmentation is sustained and expanded by historical and on-going development, and enhanced by frequent fire and associated type conversion of native vegetation communities to non-native grasslands.	(Zedler and Scheid, 1988; Case and Fisher, 2001; Holway, 2005; Leyva et al., 2006)

Nitrogen deposition	Nitrogen deposition associated with invasive cover- may promote invasive plant species, may alter soil chemistry. Studies have been conducted in Los Angeles and Riverside counties, in areas of high nitrogen deposition. Relative importance of nitrogen deposition as a factor in San Diego County is unknown, and relative importance of nitrogen versus fire as a driver of non-native cover is uncertain.	(Westman, 1981a; Zink et al., 1995; Padgett and Allen, 1999; Padgett et al., 1999; Talluto and Suding, 2008)
Climate change	Climate change is predicted to favor grasslands and decrease shrubland cover, including CSS, directly through changed climatic conditions and indirectly through fire.	(Hayhoe et al., 2004; Lenihan et al., 2008)
Natural Drivers:		
Fire frequency	Although California shrublands are considered fire adapted, unseasonal human ignitions, coupled with non-native grasses and Santa Ana Winds reduce the fire return interval, subjecting Coastal Sage Scrub to immaturity risk and type conversion to non-native grasslands.	(Zedler and Scheid, 1988; Callaway and Davis, 1993; Haidinger, 1993; Keeley, 2002; Keeley and Brennan, 2012)
Location & Topography	Abiotic factors broadly associated with composition of CSS. Slope, soils, distance inland, aridity are environmental correlates thought to drive composition and diversity of CSS stands, and mosaics of these variables contribute to CSS diversity and structure across the landscape. Important across the region in determining broadly classified types (e.g. Diegan, Riversidean), and locally associated with relative abundance of community dominants and diversity of species.	(Kirkpatrick and Hutchinson, 1977; Axelrod, 1978; Kirkpatrick and Hutchinson, 1980; Gray and Schlesinger, 1981; Westman, 1981b, a; Davis, Stine, and Stoms, 1994)
Precipitation, temperature, climate	Particularly important in their effects on fire frequency and intensity (e.g. droughts, Santa Ana winds) in addition to acting as drivers of community composition. Richness of CSS is largely driven by its native forb community which can vary annually with rainfall and timing of rainfall, and more broadly driven by topographic heterogeneity	(Kirkpatrick and Hutchinson, 1980; Westman, 1981b, a; Keeley, 2002; Hayhoe et al., 2004)
Community Variables:		
Native shrubs	Native shrub cover is the primary determinant of CSS identity, a driver of habitat characteristics for associated vertebrates, a factor in fire-frequency and intensity, and a driver of ecosystem function.	(Keeley et al. 1995;Westaman 1981b; Diffendorfer et al. 2007; Fleming, Diffendorfer, and Zedler, 2009)
Native forbs	Diversity of forbs is a major contributor to plant diversity in CSS. The importance of native forbs in driving ecosystem function and faunal diversity is an identified uncertainty.	(Westman 1981; Fleming, Diffendorfer, and Zedler, 2009;)
Non-native grasses	Non-native grasses are identified here as contributing an uncertain component to aspects of community structure. The impacts of non-native grasses on CSS are thought to be different from that of forbs, particularly in their effects on fire and structure (Grasses promote fire under some conditions).	(Keeley et al. 1995; Eliason and Allison 1998; Diffendorfer et al 2007; Fleming,; Diffendorfer, and Zedler, 2009)

Non-native forbs	Non-native forbs are identified here as contributing an uncertain component to aspects of community structure. The impacts of non-native forbs on CSS are less well studied than non-native grasses, but are thought to be different, and non-native forb cover often increases in response to management of non-native grasses.	(Diffendorfer et al. 2007; Fleming, Diffendorfer, and Zedler, 2009; DeSimone 2011)
Animal diversity	An aspect of the CSS community of central management concern. Relationship between animal diversity and CSS diversity at a local level is unclear, and very likely differs between taxa and spatial scales.	(DeSimone and zedler, 1999; Chase et al., 2000; Case and Fisher, 2001; Rubinoff, 2001; Burger et al., 2003; Longcore, 2003; Diffendorfer et al., 2007)
Ecosystem function	Promoted as a management goal, but poorly identified and defined.	(Gray and Schlesinger, 1981; Padgett and Allen, 1999; Padgett et al., 1999; Diffendorfer et al., 2007)

Monitoring Targets:	
Native shrubs	Diversity, structure and cover
Non-native grasses	Total cover
Non-native forbs	Total cover
Animal diversity	Proposed targets include herpetofauna, avifuana, ants, butterflies
Ecosystem function	Undefined. Potential targets are annual growth, decomposition rates, fractional cover…

Management Actions:	
A	Reducing excessive fire frequency
B	Reducing non-native cover, particularly grasses, de-thatching
C	Restoration and enhancement through native plant establishment
D	Prescribed fire/fire alternatives (clearing)
E	

Critical Uncertainties:	
A	Defining and measuring ecosystem function
B	Contribution of native forb diversity to animal diversity and ecosystem function
C	Role of nitrogen deposition in San Diego County
D	Climate change
Others:	Role of non-natives in animal diversity and ecosystem function

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Key Literature for: CSS Conceptual Model

Due to the large number of research papers on coastal sage scrub, the six articles below were chosen to provide entry points into the extensive literature relating to CSS classification, fire, invasive plants, and pollution. The emphasis is on recent papers that include citations for earlier research.

References	**Annotation**
Westman 1981. *Diversity Relations and Succession in Californian Coastal Sage Scrub*	A classic introduction to Coastal Sage Scrub in California. Showed that alpha richness/diversity in CSS varies primarily with abundance of herbaceous annuals, which is driven largely by time since fire, fire intensity, precipitation, temperature, shrub cover, soil nitrogen, and topographic factors. I believe it also covers slope, aspect, elevation, etc. yes?
Keeley et al. 2005. A*lien plant dynamics following fire in mediterranean climate CaliforniasShrublands*	Representative of the many research articles on the importance of fire in structuring CSS. Alien cover was low in first postfire year but increased with year in CSS. Alien cover also increased with increased precipitation. Nitrogen deposition and distance from coast were not significant predictors of alien dominance. Woody shrubs appear to be the most critical element controlling alien invasion and persistence. Alteration of fire regime (e.g., increase in frequency) changes the selective regime to favor aliens. Includes a conceptual model of CSS and fire dynamics (see attached Figure 1).
Fleming et al. 2009. *The relative importance of disturbance and exotic-plant abundance in California coastal sage scrub*	Used veg monitoring data from Camp Pendleton to assess correlation between disturbance (fire, agriculture, grazing, etc.) and exotic species abundance in CSS. Disturbance was only moderately related to exotic abundance, with fire frequency showing the strongest association. Frequent fire has negative effects on the dominant native woody species, but native perennial and annual herbs appear to receive some benefit. Found support for the idea that CSS is sensitive to novel disturbances, such as altered fire regime, and cautioned that any disturbance may increase exotic abundance. Includes simple conceptual model (see attached Figure 2)
Diffendorfer et al. 2007. *Developing terrestrial, multi-taxon indices of biological integrity: An example from coastal sage scrub*	An entry point into management debates over how to monitor and assess coastal sage scrub integrity. IBIs are developed from a gradient of disturbance, where undisturbed sites are considered to have high integrity. Authors generated a 15-metric, multitaxa IBI for CSS and argue it improves on single-species and indicator-based approaches due to the complex variability in the system. Although exotic cover and native cover were highly correlated with results based on a multi-taxa IBI, additional information related to disturbance and animal diversity was accounted for by the IBI.
Talluto and Suding 2008. *Historical change in coastal sage scrub in southern California, USA in relation to fire frequency and air pollution*	Authors resampled plots from the 1930s to test whether fire frequency and nitrogen deposition are associated with conversion of CSS to nonnative grassland. Grassland encroachment was positively correlated with increased fire frequency and, in areas with low fire frequencies, air pollution (likely correlated with N deposition). Over 76 years, CSS cover declined by 49%, being replaced predominantly by grassland.
Davis et al. 1994. *Distribution and conservation status of coastal sage scrub in southwestern California*	An overview of conservation status and broad categories of coastal sage scrub throughout Southern California. A large proportion of the mapped distribution of CSS was found to be on private land, and several taxa show < 4% of mapped distribution in nature reserves.
Crooks and Soule. 1999. *Mesopredator release and avifaunal extinctions in a fragmented system.*	An investigation of predator (coyote and cat) dynamics in fragmented CSS habitat, suggesting that CSS fragmentation and increases in cat predation on birds and lizards may have large consequences for native animal populations in fragmented patches of CSS.

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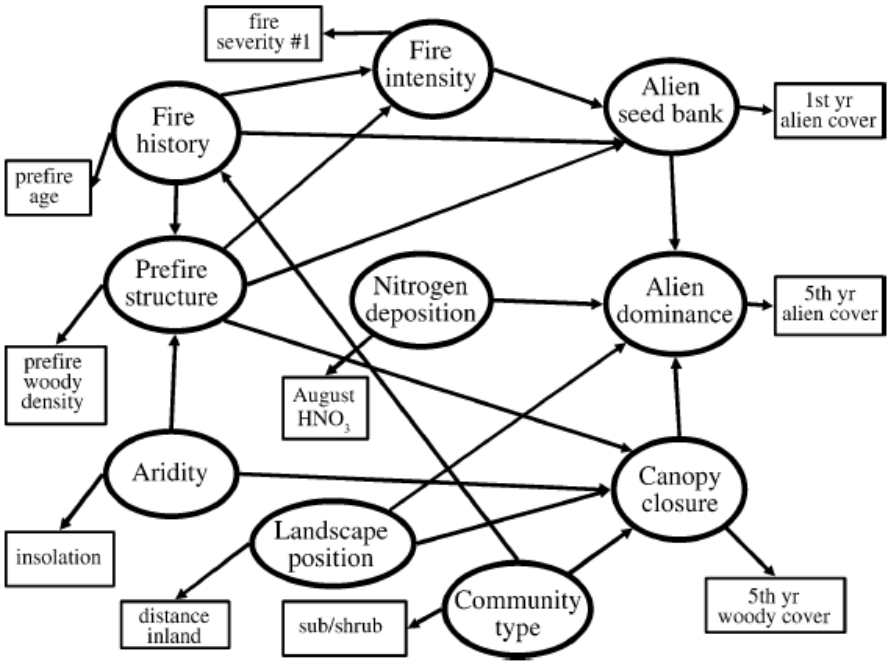


FIG. 1. (Keeley et al. 2005) Initial conceptual model of factors driving alien success in southern California shrublands. Hypothesized effects are represented by arrows connecting conceptual or latent variables (ellipses). Measured variables (rectangles) make up the data matrix that tests these hypotheses with covariance analysis and provides a statistical evaluation of the correspondence between the hypothesized path model and the data. See Methods for detailed description of variables.

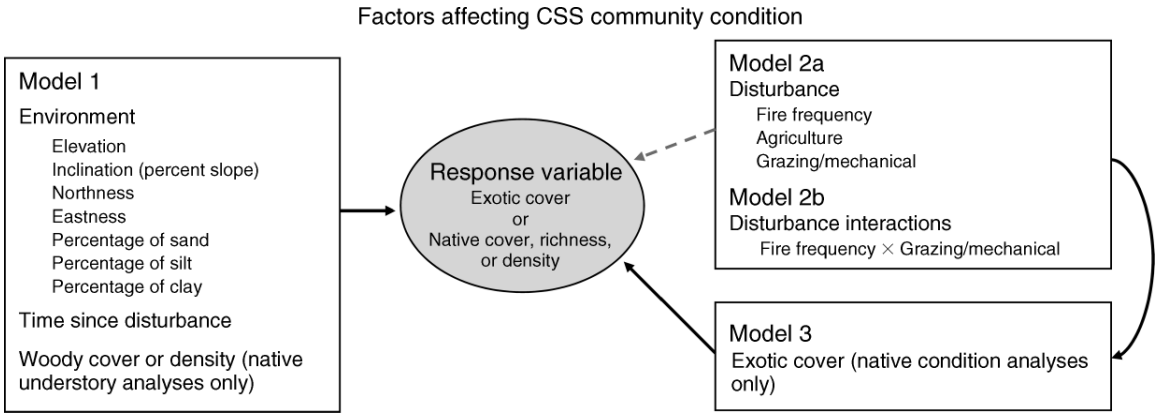
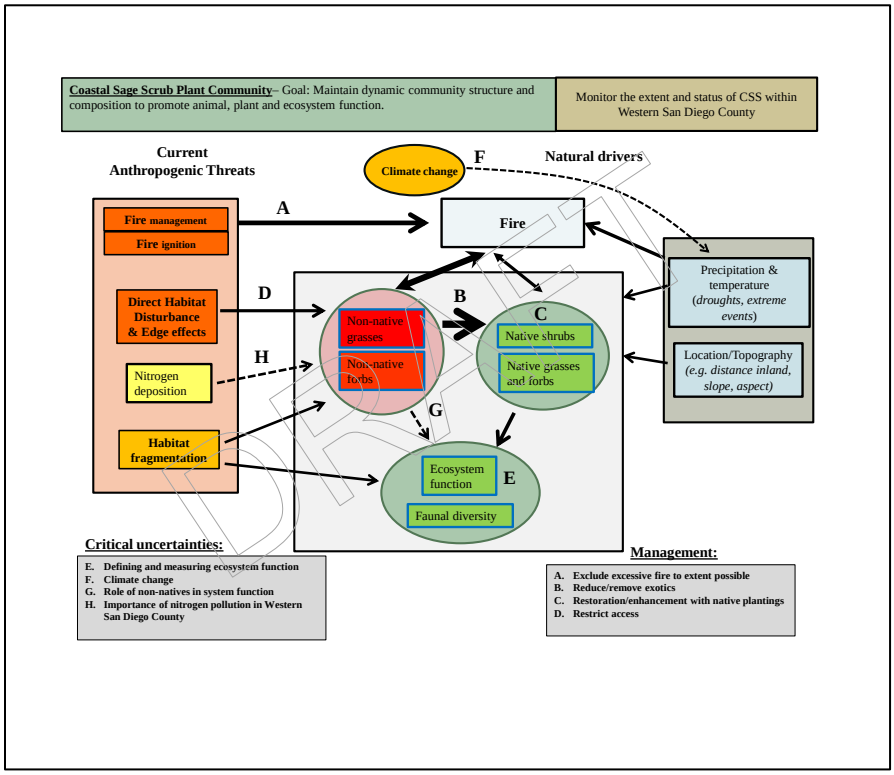
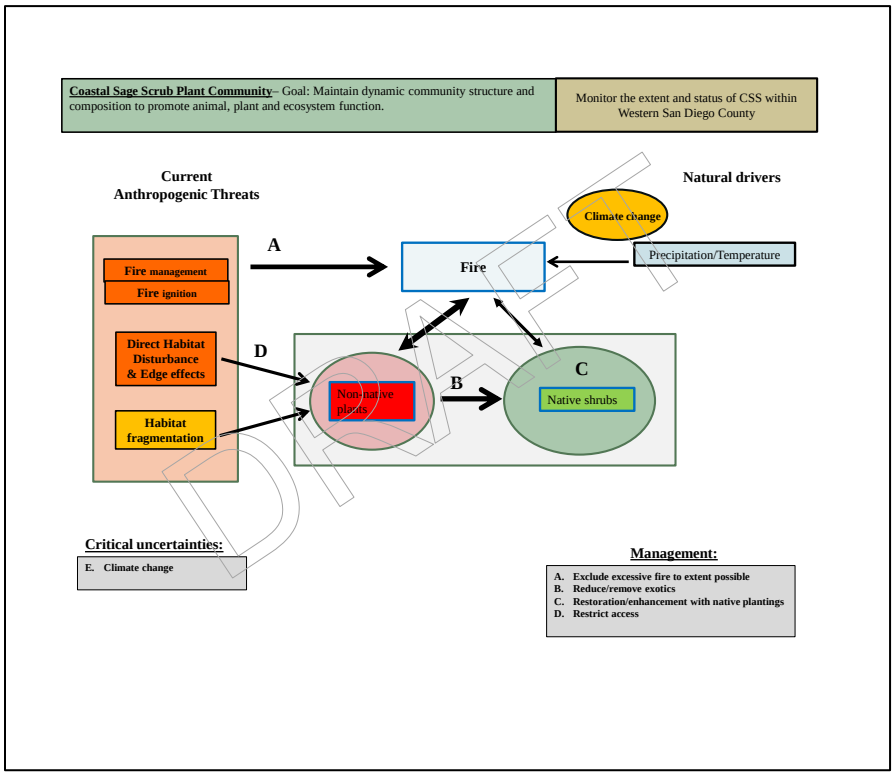
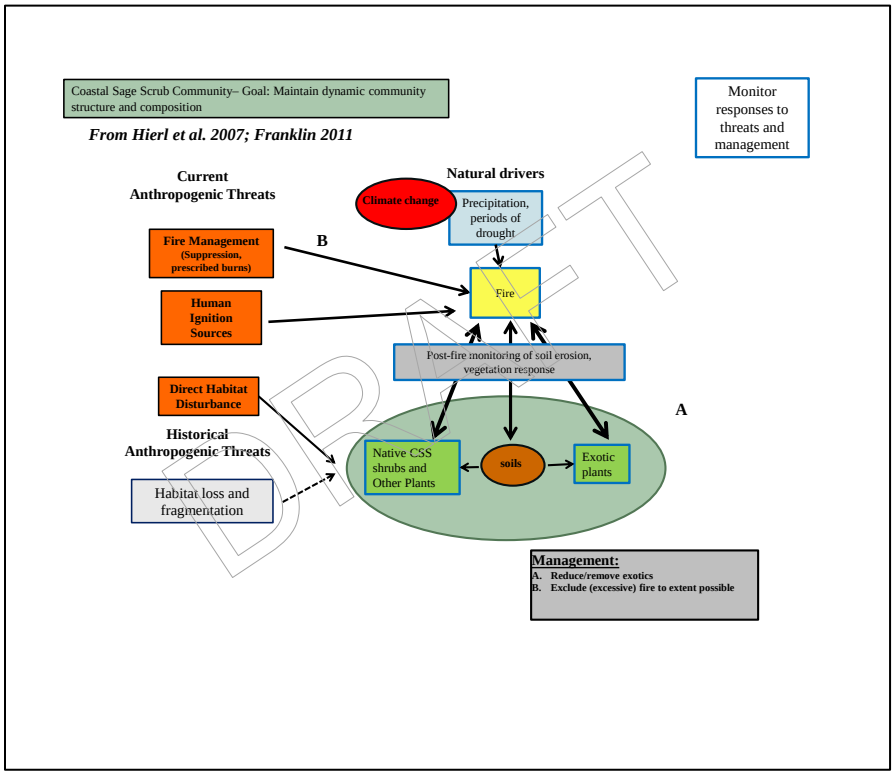


FIG. 2. (Fleming et al. 2009) The conceptual model used to determine the entry order of explanatory variable sets into hierarchical regression analyses. Variables with fundamental impacts on various aspects of California coastal sage scrub (CSS) community condition (response variable) were entered in Model 1. Of the environmental variables listed, only a subset was included in any given analysis based on preliminary analyses. Woody cover or density was included only in analyses examining native understory elements (herb cover and richness or woody seedling density). Specific disturbance types and disturbance interactions were entered in Model 2a and 2b. When examining native plant cover, richness, or density, exotic cover was entered in Model 3 to examine, in part, whether any apparent disturbance effects (represented by dashed arrow) were possibly mediated by exotic abundance. Exotic-mediated (indirect) disturbance effects are represented by the influence of disturbance on exotic cover (solid arrow) and the influence of exotic cover on the response variable.

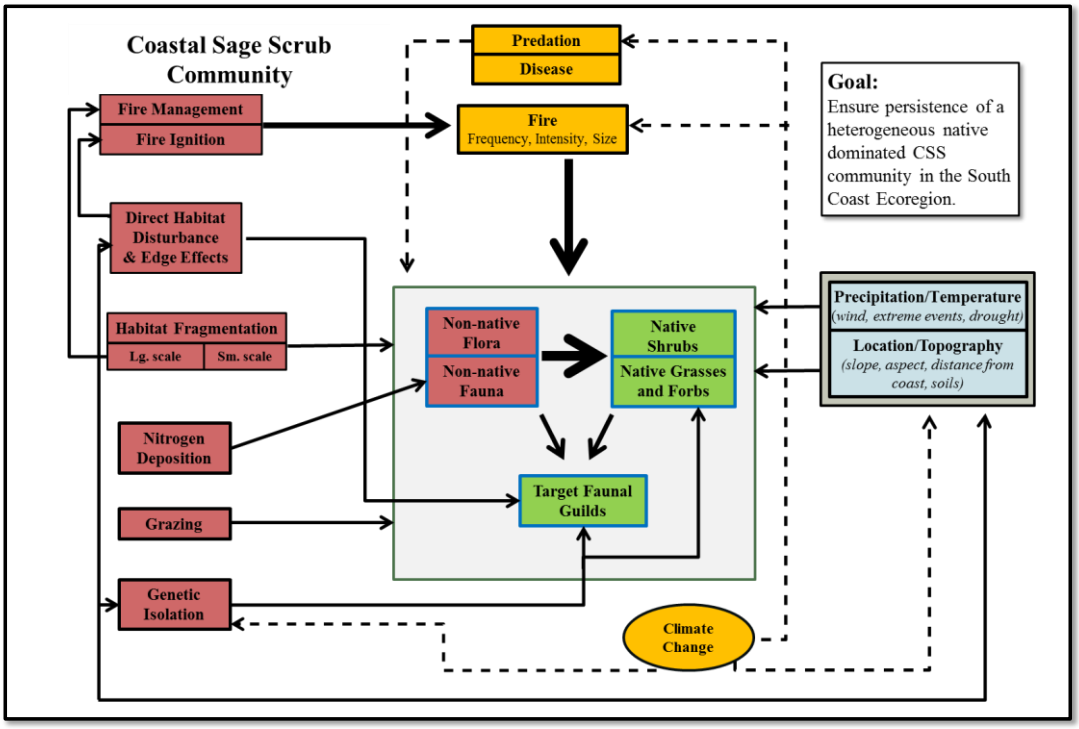
Draft Models for: CSS Conceptual Model






Coastal Sage Scrub Community– Goal: Maintain dynamic community structure and composition
From Hierl et al. 2007; Franklin 2011
Monitor responses to threats and management
Current Anthropogenic Threats
Natural drivers
Climate change
Precipitation, periods of drought
Fire Management (Suppression, prescribed burns)
B
Fire
Human Ignition Sources
Post-fire monitoring of soil erosion, vegetation response
Direct Habitat Disturbance
A
Historical Anthropogenic Threats
Native CSS shrubs and Other Plants
soils
Exotic plants
Habitat loss and fragmentation
Management:
A. Reduce/remove exotics
B. Exclude (excessive) fire to extent possible

Final Model *for: CSS Conceptual Model*



Key:

- Anthropogenic threat
- Community variable
- Natural driver
- Human modified natural driver
- Blue line denotes monitoring target
- Documented element
- Element with uncertainty

(Arrow thickness denotes importance)

Critical uncertainties:

1. Identification of CSS reference conditions
2. Targets and thresholds
3. Fire management approaches
4. Future land-use change
5. Climatic change
6. Effect of nitrogen deposition in S.C. Ecoregion
7. Genetic relationships and their relevance

Management:

1. Reduce/remove exotic species
2. Restoration or enhancement of CSS using local genetic stock
3. Restrict unauthorized/inappropriate public access

Recreation Conceptual Model

Narrative for: Recreational Trails and Access Control Conceptual Model

Goals:		
Management	Balance the protection of biological and cultural resources with recreational use	
Monitoring	Monitor the impacts of recreational use	
Anthropogenic Threats:		
Off-Road Vehicles	Vegetation Disturbance: Creates destruction and loss of vegetation	Fang et al. 2010; Groom et al. 2007; Li et al. 2007; Sampson 2007; Rickard et al. 1994; Griggs & Walsh 1981; Brodhead & Godfrey 1977
	Soil Disturbance: Soil erosion and compaction; sediment discharge; creates dust	Fang et al. 2010; Goosens & Buck 2009; Schlacher & Thompson 2008; Li et al. 2007; Pickering & Hill 2007; Sack & da Luz 2003; Griggs & Walsh 1981
	Wildlife Disturbance: Direct mortality (crushing animals); changes in behavior; decreases in survival and reproduction	Previtali et al. 2010; Tarr et al. 2010; Sheppard et al. 2009; Sampson 2007; Schlacher & Thompson 2007; Schlacher et al. 2007; Preisler et al. 2006; Pomerantz 1988
	Non-native Plants: Introduce and spread non-native plants	Pickering & Hill 2007
	Cultural Resource Disturbance: deflation of cultural deposits; displacement and damage to artifacts; providing access to remote archaeological sites, making them more vulnerable to looters and vandals	Jarvis 2008; Sampson 2007

Horses	Vegetation Disturbance: Trampling vegetation	Pickering et al. 2010; Törn et al. 2009; Cole & Spildie 1998
	Soil Disturbance: Soil erosion and compaction; nitrification of soils from urine and dung	Pickering et al 2010; Quinn et al. 2010; Deluca et al. 1998
	Non-native Plants: Introduce and spread non-native plants, primarily via dung	Pickering et al 2010; Quinn et al. 2010; Törn et al. 2009; Quinn et al 2008; Pickering & Hill 2007; Campbell & Gibson 2001
	Cultural Resource Disturbance: looting and vandalism	No literature found
Mountain Bikers	Vegetation Disturbance: Trampling vegetation	Lathrop 2003
	Soil Disturbance: Soil erosion and compaction	Pickering et al. 2010; Pickering & Hill 2007; Lathrop 2003
	Wildlife Disturbance: Decrease in wildlife density; cause animals to flee	Lathrop 2003; Taylor & Knight 2003
	Non-native Plants: Introduce and spread non-native plants	Pickering et al. 2010; Pickering & Hill 2007
	Cultural Resource Disturbance: looting and vandalism	No literature found
Hikers	Vegetation Disturbance: Trampling vegetation	Pickering et al. 2010; Kerbiriou et al. 2007
	Soil Disturbance: Soil erosion and compaction	Pickering et al. 2010; Pickering & Hill 2007; Deluca et al. 1998
	Wildlife Disturbance	Steven et al 2011; Taylor & Knight 2003; Freddy et al. 1986
	Non-native Plants: Introduce and spread non-native plants	Pickering et al. 2010; Mount & Pickering 2009; Whinam et al. 2005
	Cultural Resource Disturbance: looting and vandalism	No literature found
Dogs	Wildlife Disturbance	Steven et al 2011; Lenth et al. 2006; Miller 2001
	Cultural Resource Disturbance: impacts of digging and defecation	No literature found

Natural Drivers:		
Vegetation Community	Vegetation Disturbance: Vegetation communities differ in resistance to and resilience after trampling	Pickering et al. 2010; Pickering 2010; Hill & Pickering 2009; Gallet et al. 2004; Cole 1998; West 1997; Yu-Fai & Marion. 1996; Cole 1995; Rickard 1994
	Non-native Plants: Vegetation communities differ in invasibility	Going et al. 2009; Burke & Grime 1996
Slope/ Topography	Soil Disturbance: Can affect degree of erosion	Pickering 2010; Yu-Fai 1996
	Vegetation Community: Can affect resistance/ resilience of vegetation community	Kuss 1986
Soil Characteristics	Soil Disturbance: Can affect degree of erosion	Pickering 2010; Yu-Fai 1996
	Vegetation Community: Can affect resistance/ resilience of vegetation community	Kuss 1986
Climatic Variables	Soil Disturbance: Precipitation can affect severity of erosion	Pickering 2010; Yu-Fai 1996
	Vegetation Community: Can affect resistance/ resilience of vegetation community	Kuss 1986
Monitoring Targets:		
This will be a key point of our discussion during the workshop		
Management Actions:		
A	Vehicle Barriers	
B	Fencing	
C	Trail Rerouting	
D	Trail Closure	
E	Increased enforcement	
F	Signage	
G	Environmental Outreach Programs	
Critical Uncertainties:		
H	Impacts on cultural resources	
I	Relationship between authorized and unauthorized user impacts	
J	How recreation user attitude/ satisfaction affects recreation impacts	
K	Dogs: should they be together with or separate from hikers in the model?	
L	Climate change	

Key Literature for: Recreational Trails and Access Control Conceptual Model

1st Tier: Most important to read

References	Annotations
Pickering et al. 2010 *Comparing hiking, mountain biking, and horse riding impacts on vegetation and soils in Australia and the United States of America* Journal of Environmental Management 91:551-562	Review paper summarizing the impacts of hiking, horse riding, and mountain biking on vegetation, soils, and trails. Compares studies from Australia and the United States. Many impacts are similar for the three activities but can differ in severity. Impacts include damage to existing trails, soil erosion, compaction and nutrification, changes in hydrology, trail widening, exposure of roots, rocks and bedrock. Identifies current gaps in research, including the need for more research on horse and mountain bike impacts, for studies that directly compare types and severity of impacts among activities, and on the potential for each activity to contribute to the spread of non-native plants and plant pathogens.
Pickering 2010 *Ten factors that affect the severity of environmental impacts of visitors in protected areas* AMBIO 39:70-77	Identifies and explains ten factors that affect how much recreational users damage protected areas. Examples of these factors include resistance, resilience, susceptibility to erosion, timing of use, and size of area impacted.
Reed and Merenlender 2008 *Quiet, non-consumptive recreation reduces protected area effectiveness* Conservation Letters 1-9	Surveys for mammalian carnivores in protected areas with and without recreation revealed a five-fold decline in the density of native carnivores and a substantial shift from native to non-native species in the areas with recreation.

2nd Tier: Important to read

References	Annotations
Quinn et al. 2010 *Role of horses as potential vectors of non-native plant invasion: an overview* Natural Areas Journal 30:408-416	Review paper looking at the connection between horses and non-native plant invasions. Also looks at other impacts of horses, including trampling vegetation, soil disturbance, and increased soil nitrogen. Recommends development of best management practices such as weed education programs for equestrians, use of Certified Weed Free Feed, and the use of manure bunkers.
Lathrop 2003 *Ecological impacts of mountain biking: a critical literature review* Wildlands CPR June 29, 2003	Review paper looking at the impacts of mountain biking, specifically vegetation trampling, erosion, and wildlife disturbance.
Reed and Merenlender 2011 *Effects of management of domestic dogs and recreation on carnivores in protected areas in Northern California* Conservation Biology 25(3):504-513	Explores the relationship between carnivore species richness and abundance with management of domestic dogs and recreational visitation in protected areas. Found that policy on domestic dogs did not affect carnivore richness and abundance. However, the number of dogs was strongly associated with number of humans, so key factors with effects on carnivores appears to be the number of human visitors.
Sampson 2007 *Effects of off-highway vehicles on archaeological sites in Red Rock Canyon* California State Parks Report *http://www.parks.ca.gov/?page_id=24576*	Investigation of ORV impacts at Red Rock Canyon State Park, with a focus on archaeological sites. Damage from vehicles includes vehicle scars, loss of soils and vegetation, gullying, deflation of cultural deposits, displacement and damage to artifacts and geologic features. Management options include installation of vehicle barriers, route closures, public education, increased patrol, erosion-control measures, and restoration of damaged terrain.

3rd Tier: Supplementary literature

(Grouped by topic, some repeats among groups)

Off-Road Vehicles

Brodhead, J.M., Godfrey, P.J. 1977. Off road vehicle impact in Cape Cod National Seashore: disruption and recovery of dune vegetation. *International Journal of Biometeorology* 21(3): 299-306

Fang, S., Gertner, G.Z., Anderson, A.B., Howard, H.R., Sullivan, P., Otto, C. 2010. Prediction and uncertainty source analysis of the spatial and temporal disturbance from off-road vehicular traffic in a complex ecosystem. Journal of *Environmental Management* 91:772-780

Goosens, D., Buck, B. 2009. Dust dynamics in off-road vehicle trails: measurements on 16 arid soil types, Nevada, USA. *Journal of Environmental Management* 90:3458-3469

Grant, T.J., Doherty, P.F. 2009. Potential mortality effects of off-highway vehicles on the flat-tailed horned lizard (*Phrynosoma mcallii*): a manipulative experiment. *Environmental Management* 43:508-513

Griggs, G.B., Walsh, B.L. 1981. The impact, control, and mitigation of off-road vehicle activity in Hungry Valley, California. *Environmental Geology & Water Sciences* 4(3):229-243

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

Li, Q., Ayers, P.D., Anderson, A.B. 2007. Effects of vehicle speed and turning radius of off-road vehicles on terrain impact severity. *Applied Engineering in Agriculture* 23(6):701-708

Pickering, C.M., Hill, W. 2007. Impacts of recreation and tourism on plant biodiversity and vegetation in protected areas in Australia. *Journal of Environmental Management* 85:791-800

Pomerantz, G.A., Decker, D.J., Goff, G.R., Purdy, K.G. 1988. Assessing impact of recreation on wildlife: a classification scheme. *Wildlife Society Bulletin* 16(1):58-62

Preisler, H.J., Ager, A.A., Wisdom, M.J. 2006. Statistical methods for analyzing responses of wildlife to human disturbance. *Journal of Applied Ecology* 43:164-172

Previtali, M.A., Lehmer, E.M., Pearce-Duvet, J.M., Jones, J.D., Clay, C.A., Wood, B.A., Ely, P.W., Laverty, S.M., Dearing, M.D. 2010. Roles of human disturbance, precipitation, and a pathogen on the survival and reproductive probabilities of deer mice. *Ecology* 91(2):581-592

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Sheppard, N., Pitt, K.A., Schlacher, T.A. 2009. Sub-lethal effects of off-road vehicles (ORVs) on surf clams on sandy beaches. *Journal of Experimental Marine Biology and Ecology* 380:113-118

Tarr, N., Simons, T.R., Pollock, K.H. 2010. An experimental assessment of vehicle disturbance effects on migratory shorebirds. *Journal of Wildlife Management* 74(8):1776-1783

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Deluca, T.H., Freimund, W.A., Cole, D.N. 1998. Influence of llamas, horses, and hikers on soil erosion from established trails in western Montana, USA. *Environmental Management* 22:255-262

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Hikers

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Kerbiriou, C., Leviol,I., Frederic, J., Julliard, R. 2008. The impact of human frequentation on coastal vegetation in a biosphere reserve. *Journal of Environmental Management* 88:715-728

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Miller, S.G., Knight, R.L., Miller, C.K. 2001. Responses to pedestrians and dogs. *Wildlife Society Bulletin* 29(1):124-132

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Comita, L.S., Goldsmith, G.R. 2008. Impact of research trails on seedling dynamics in a tropical forest. *BIOTROPICA* 40(2):251-254

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Fletcher, R.J., McKinney, S.T., Bock, C.E. 1999. Effects of recreational trails on wintering diurnal raptors along riparian corridors in a Colorado grassland. *Journal of Raptor Research* 33(3):233-239

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Potito, A.P., Beatty. S.W. 2005. Impacts of recreation trails on exotic and ruderal species distribution in grassland areas along Colorado front range. *Environmental Management* 36(2):230-236

Riffell, S.K., Gutzwiller, K.T., Anderson, S.H. 1996. Does repeated human intrusion cause cumulative declines in avian richness and abundance? *Ecological Applications* 6(2):492-505

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Natural Drivers

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Hill, R., Pickering, C. 2009. Differences in resistance of three subtropical vegetation types to experimental trampling. Journal of Environmental Management 90:1305-1312

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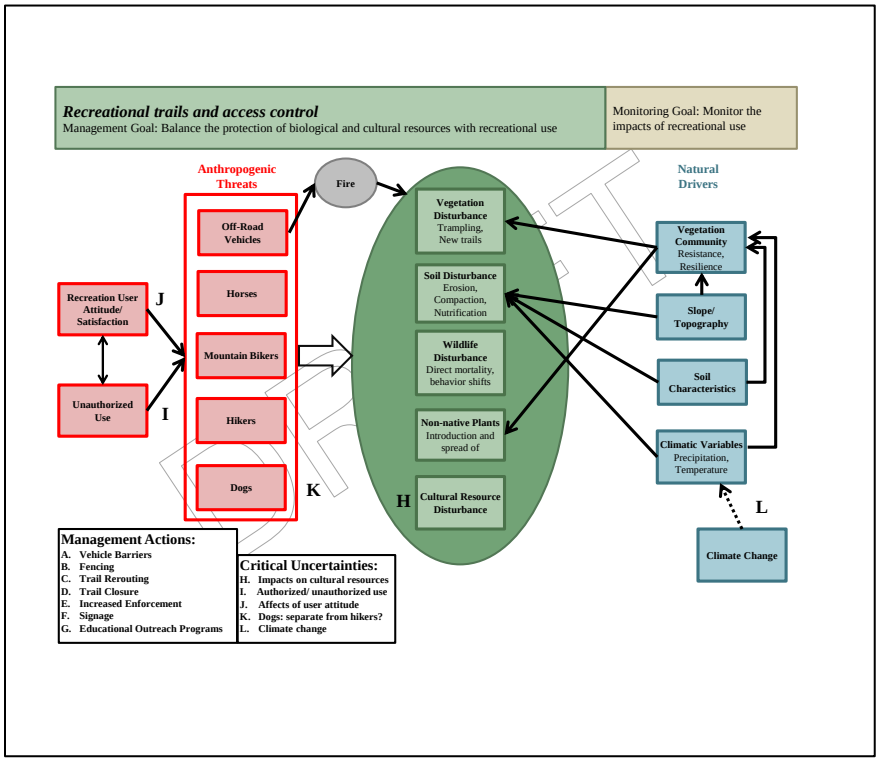
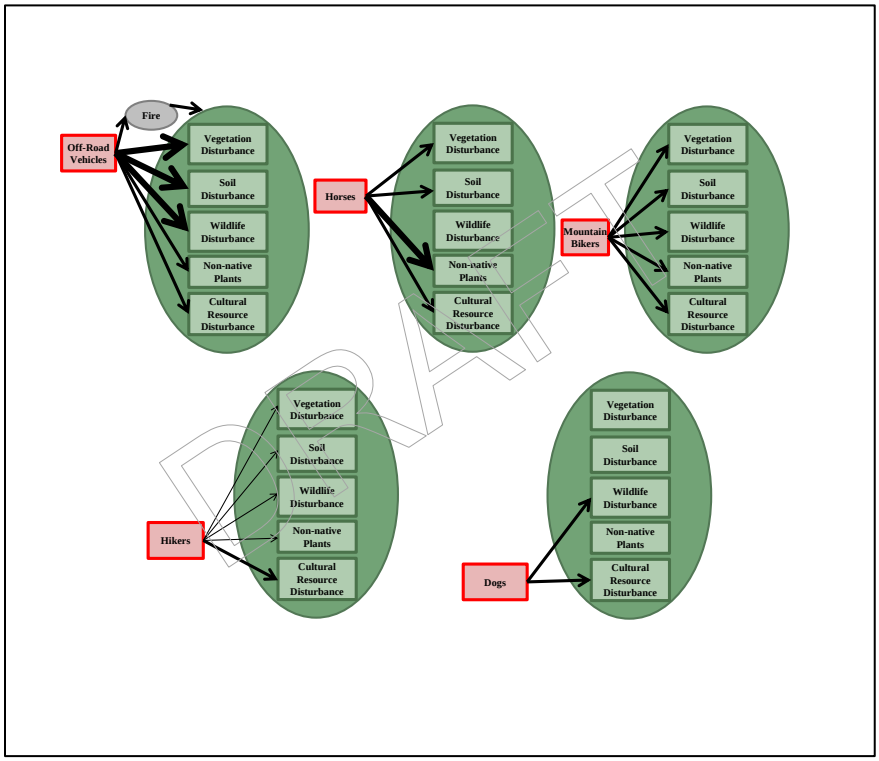
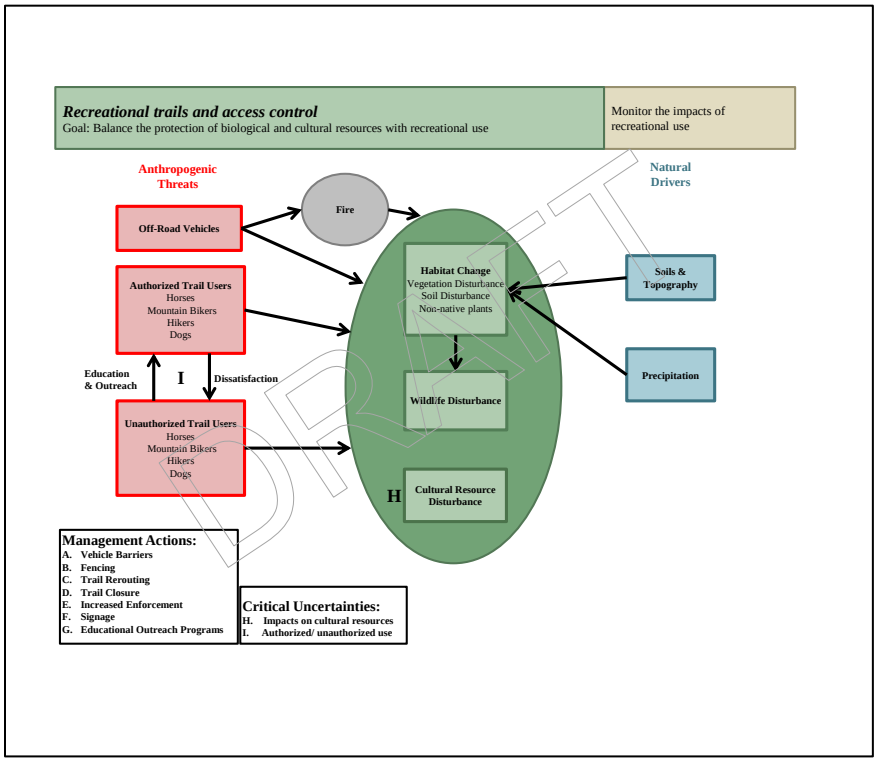
West, N.E., Mueller, R.J., Warren, S.D. 1997. Toleration of traffic by vegetation: life form conclusions and summary extracts from a comprehensive data base. *Environmental Management* 21(1): 121-131

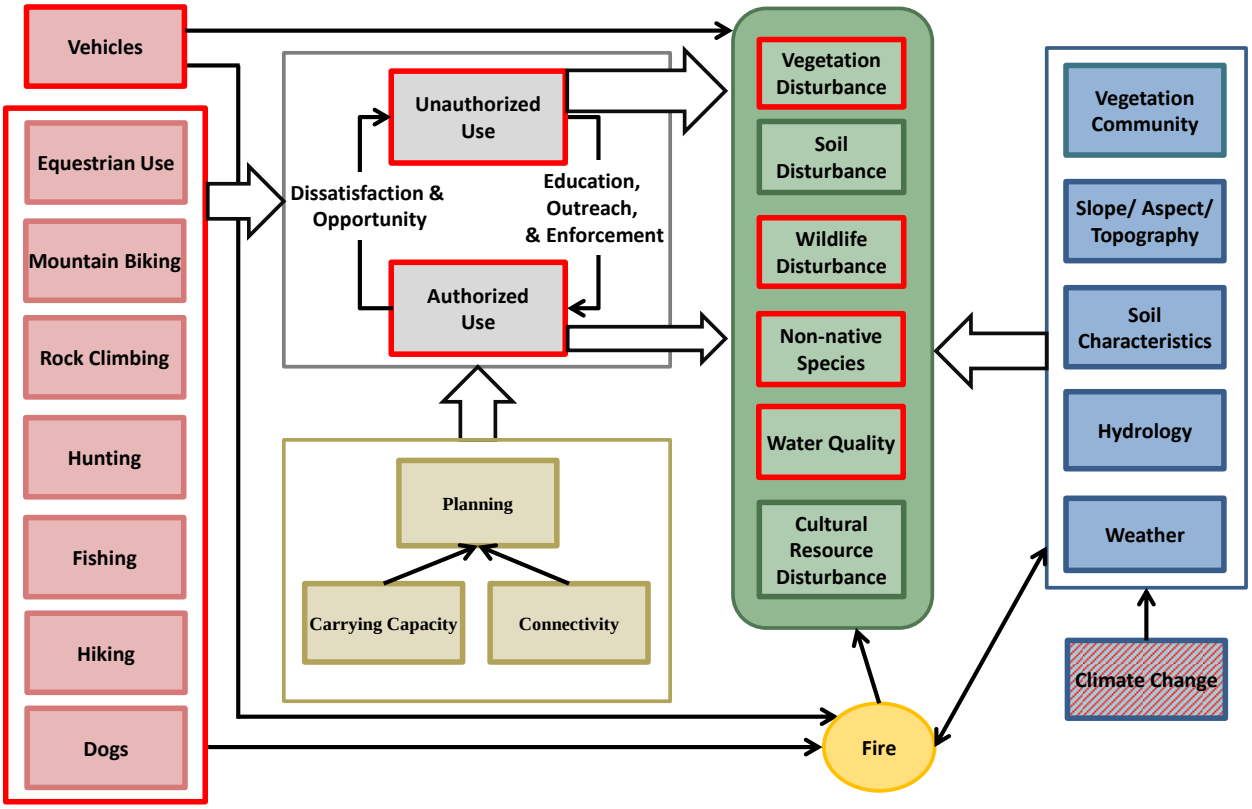
Draft Models for: Recreational Trails and Access Control Conceptual Model



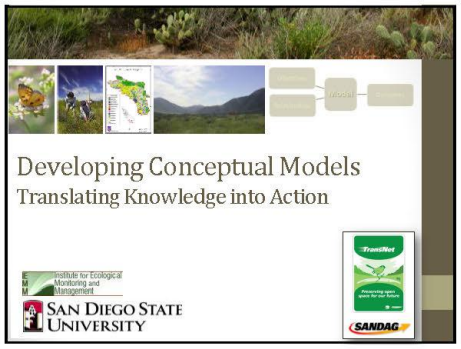


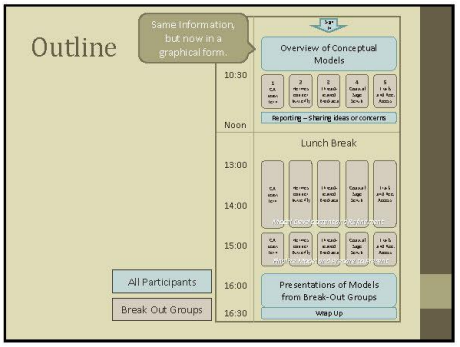

Recreational trails and access control
Goal: Balance the protection of biological and cultural resources with recreational use
Monitor the impacts of recreational use
Anthropogenic Threats
Natural Drivers
Off-Road Vehicles
Fire
Authorized Trail Users
Horses
Mountain Bikers
Hikers
Dogs
Habitat Change
Vegetation Disturbance
Soil Disturbance
Non-native plants
Soils & Topography
Precipitation
Education & Outreach
I
Dissatisfaction
Wildlife Disturbance
Unauthorized Trail Users
Horses
Mountain Bikers
Hikers
Dogs
H
Cultural Resource Disturbance
Management Actions:
A. Vehicle Barriers
B. Fencing
C. Trail Rerouting
D. Trail Closure
E. Increased Enforcement
F. Signage
G. Educational Outreach Programs
Critical Uncertainties:
H. Impacts on cultural resources
I. Authorized/ unauthorized use

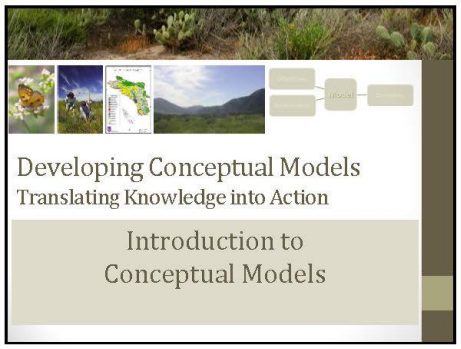
***Final Model** for: Recreational Trails and Access Control Conceptual Model*

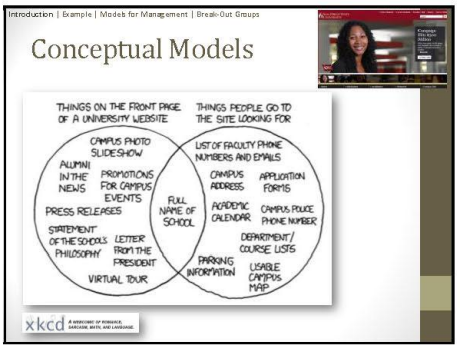


APPENDIX 6 –IEMM PRESENTATION ON CONCEPTUAL MODELS





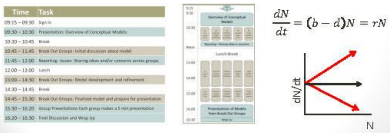




Introduction | Example | Models for Management | Break-Out Groups

Conceptual Models

- **Conceptual Models** allow us (force us?) to make explicit many of our implicit assumptions and ideas.
- They may be **text**, **graphics**, or **equations**.



$$\frac{dN}{dt} = (b - d)N = rN$$

Introduction | Example | Models for Management | Break-Out Groups

Conceptual Models

- Deciding on the appropriate level of detail and complexity is both important and difficult
  - Complexity (Realism?) vs Parsimony
  - Decision should be based on the monitoring and/or management objectives of the model

Introduction | Example | Models for Management | Break-Out Groups

Conceptual Models

WWF. 2005. Guidance for Cross-Cutting Tools: Conceptual Models.

1. Scope and Vision
   Objectives of the project
2. Targets
   Species, habitats (ecological systems), and/or ecological processes that you have chosen
3. Context and Stakeholders
   Direct threats and the factors (including indirect threats and opportunities) that are influencing your direct threats, including the actors behind those different factors . . .

Introduction | Example | Models for Management | Break-Out Groups

Conceptual Models

Gross JE. 2003. Developing Conceptual Models for Monitoring Programs. NPS Inventory and Monitoring Program

- Conceptual models:
  - **Formalize current understanding** of system processes and dynamics
  - **Identify linkages** of processes across disciplinary boundaries
  - **Identify the bounds and scope** of the system of interest
- and they contribute to communication
  - Among scientists
  - Between scientists and managers
  - With the general public

Introduction | Example | Models for Management | Break-Out Groups

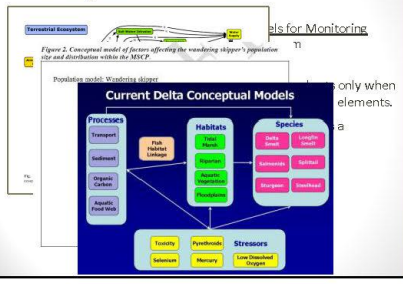
Conceptual Models

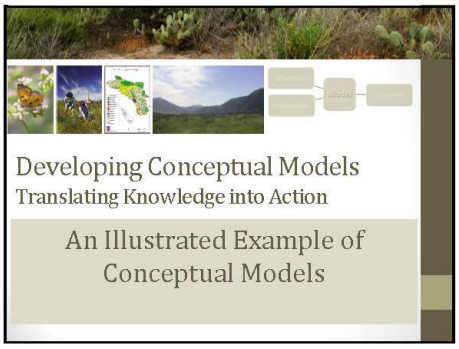
Gross JE. 2003. Developing Conceptual Models for Monitoring Programs. NPS Inventory and Monitoring Program

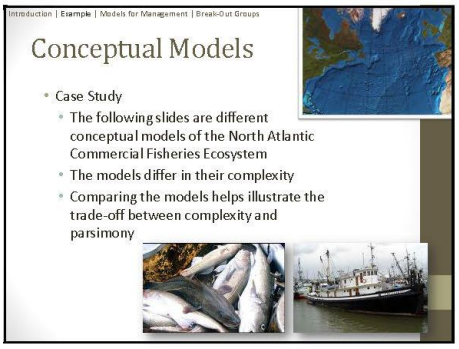
1. Clearly state the objective of the model
2. Identify bounds of the system of interest.
3. Identify key model components, subsystems, and interactions.
4. Describe relationships of natural and anthropogenic stressors, ecological factors, and responses.
5. Articulate key questions and uncertainties or possible alternative approaches.
6. Review, revise, refine models.

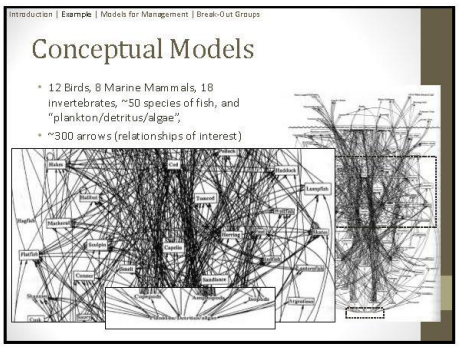
Introduction | Example | Models for Management | Break-Out Groups

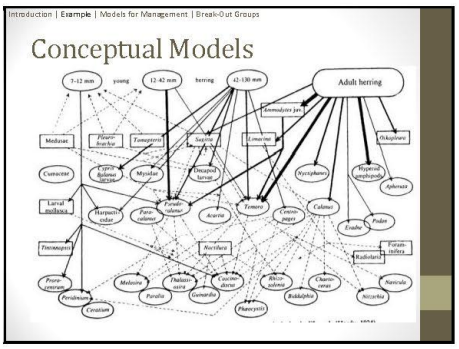
Conceptual Models

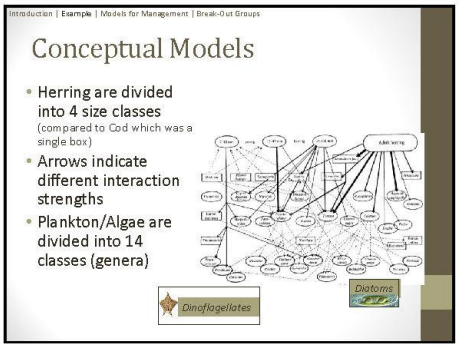


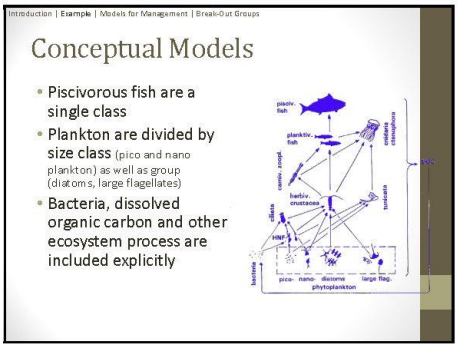

Developing Conceptual Models
Translating Knowledge into Action
An Illustrated Example of Conceptual Models


Introduction | Example | Models for Management | Break-Out Groups
Conceptual Models
Case Study
The following slides are different conceptual models of the North Atlantic Commercial Fisheries Ecosystem
The models differ in their complexity
Comparing the models helps illustrate the trade-off between complexity and parsimony


Introduction | Example | Models for Management | Break-Out Groups
Conceptual Models
12 Birds, 8 Marine Mammals, 18 invertebrates, ~50 species of fish, and "plankton/detritus/algae",
~300 arrows (relationships of interest)


Introduction | Example | Models for Management | Break-Out Groups
Conceptual Models
Adult herring

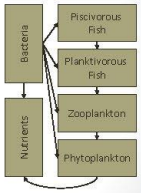

Introduction | Example | Models for Management | Break-Out Groups
Conceptual Models
Herring are divided into 4 size classes (compared to Cod which was a single box)
Arrows indicate different interaction strengths
Plankton/Algae are divided into 14 classes (genera)
Dinoflagellates
Diatoms


Introduction | Example | Models for Management | Break-Out Groups
Conceptual Models
Piscivorous fish are a single class
Plankton are divided by size class (pico and nano plankton) as well as group (diatoms, large flagellates)
Bacteria, dissolved organic carbon and other ecosystem process are included explicitly

Introduction | Example | Models for Management | Break-Out Groups

Conceptual Models

- Treats each "level" of the ecosystem as a single class
- Very simple and elegant
- Difficult to link to individual species of interest
- Difficult to image how to link with goals, management



Developing Conceptual Models

Translating Knowledge into Action

Conceptual Models for Monitoring and Management

Introduction | Example | Models for Management | Break-Out Groups

Conceptual Models

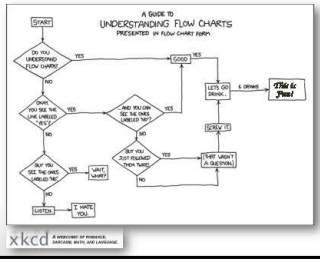
Designing Monitoring Programs in an Adaptive Management Context for Regional Multiple Species Conservation Plans

Step 1. Identify the goals and objectives of the regional conservation plan
Step 2. Identify scope of monitoring program
Step 3. Compile information relevant to monitoring program design
Step 4. Strategically divide the system and prioritize for monitoring program development
Step 5. Develop simple management-oriented conceptual models
Step 6. Identify monitoring recommendations and critical uncertainties
Step 7. Determine strategy for implementing monitoring
Step 8. Develop data quality assurance, data management, analysis, and reporting strategies
Step 9. Complete the adaptive management loop by ensuring effective feedback to decision-making

An outline or a flowchart is a conceptual model

Introduction | Example | Models for Management | Break-Out Groups

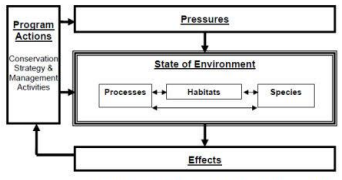
Conceptual Models



Introduction | Example | Models for Management | Break-Out Groups

Conceptual Models

Designing Monitoring Programs in an Adaptive Management Context for Regional Multiple Species Conservation Plans

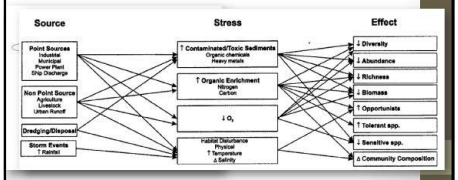


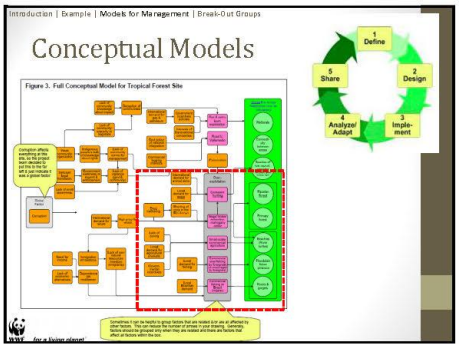
MANAGEMENT-ORIENTED CONCEPTUAL MODEL

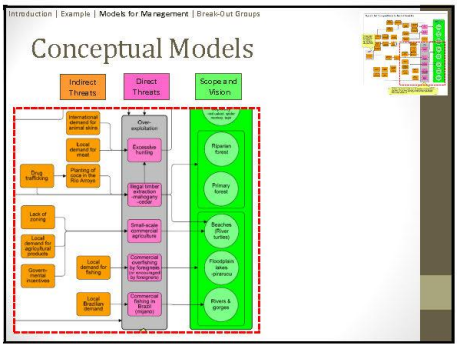
Introduction | Example | Models for Management | Break-Out Groups

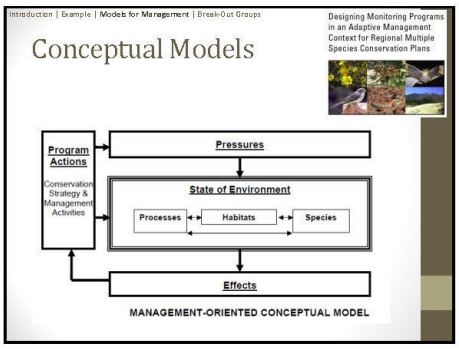
Conceptual Models

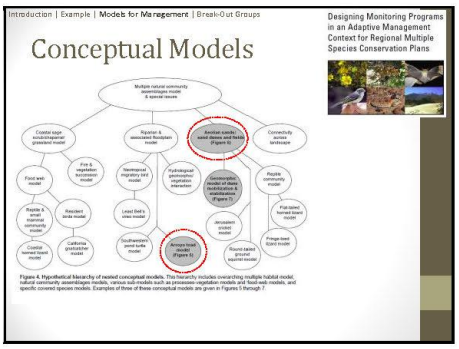
Gross JE. 2003. Developing Conceptual Models for Monitoring Programs. NPS Inventory and Monitoring Program

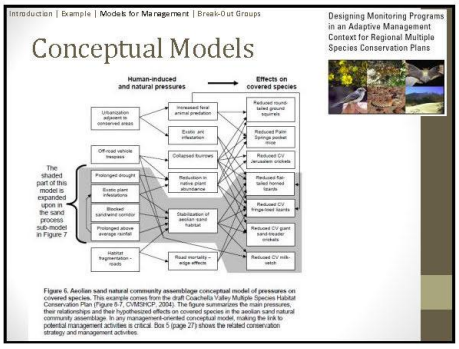


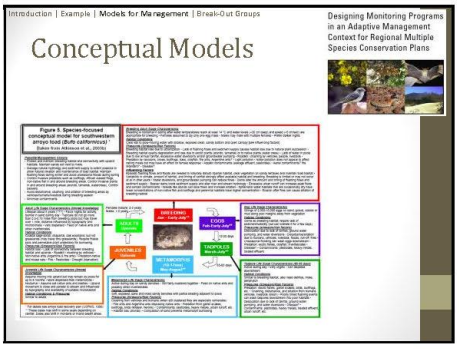

Introduction | Example | Models for Management | Break-Out Groups
Conceptual Models
1 Define
2 Design
3 Imple-ment
4 Analyze/ Adapt
5 Share

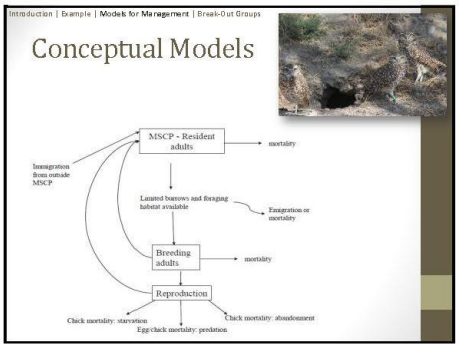

Introduction | Example | Models for Management | Break-Out Groups
Conceptual Models
Indirect Threats
Direct Threats
Scope and Vision

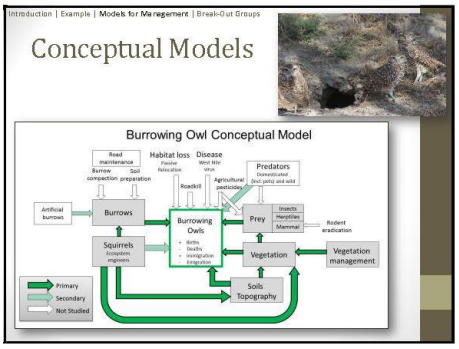

Introduction | Example | Models for Management | Break-Out Groups
Designing Monitoring Programs in an Adaptive Management Context for Regional Multiple Species Conservation Plans
Conceptual Models
Program Actions
Conservation Strategy & Management Activities
Pressures
State of Environment
Processes
Habitats
Species
Effects
MANAGEMENT-ORIENTED CONCEPTUAL MODEL

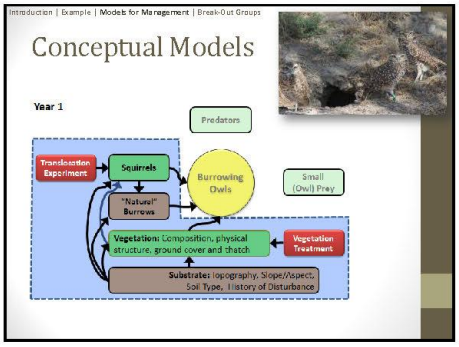

Introduction | Example | Models for Management | Break-Out Groups
Designing Monitoring Programs in an Adaptive Management Context for Regional Multiple Species Conservation Plans
Conceptual Models

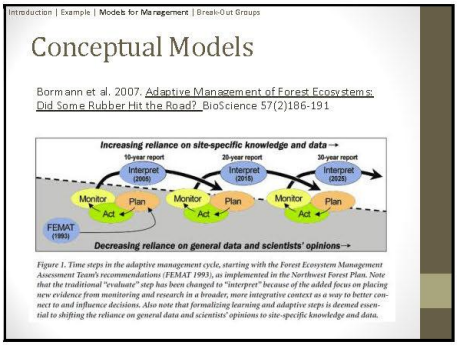

Introduction | Example | Models for Management | Break-Out Groups
Designing Monitoring Programs in an Adaptive Management Context for Regional Multiple Species Conservation Plans
Conceptual Models
Human-induced and natural pressures
Effects on covered species
The shaded part of this model is expanded upon in the sand process sub-model in Figure 7

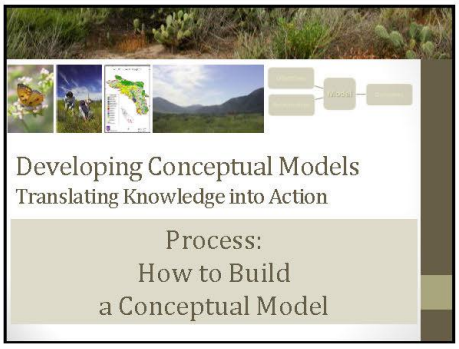

Introduction | Example | Models for Management | Break-Out Groups
Designing Monitoring Programs in an Adaptive Management Context for Regional Multiple Species Conservation Plans
Conceptual Models

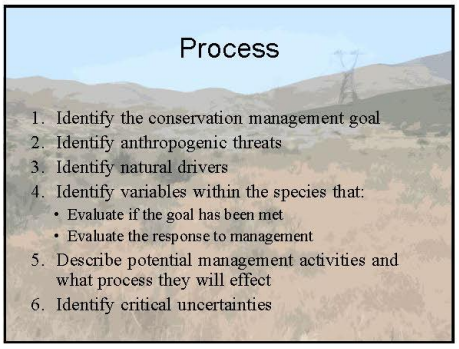

Introduction | Example | Models for Management | Break-Out Groups
Conceptual Models
MSCP - Resident adults
mortality
Immigration from outside MSCP
Limited burrows and foraging habitat available
Emigration or mortality
Breeding adults
mortality
Reproduction
Chick mortality: starvation
Egg/chick mortality: predation
Chick mortality: abandonment

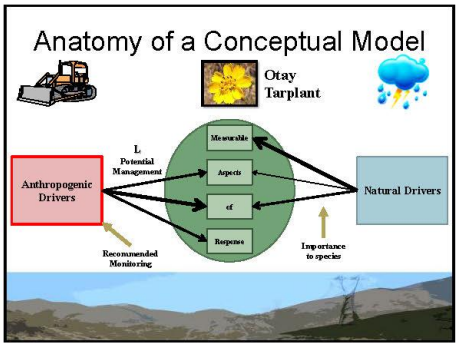

Introduction | Example | Models for Management | Break-Out Groups
Conceptual Models
Burrowing Owl Conceptual Model
Habitat loss
Disease
Predators
Roadkill
Artificial burrows
Burrows
Burrowing Owls
Prey
Squirrels
Vegetation
Vegetation management
Soils
Topography
Primary
Secondary
Not Studied

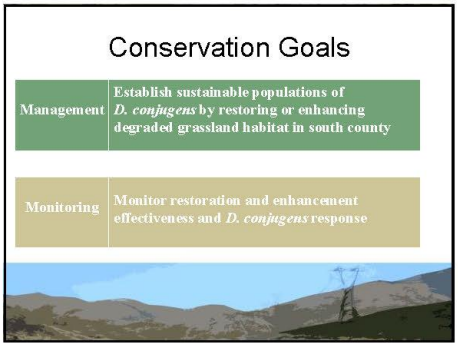

Introduction | Example | Models for Management | Break-Out Groups
Conceptual Models
Year 1
Predators
Translocation Experiment
Squirrels
"Natural" Burrows
Burrowing Owls
Small (Owl) Prey
Vegetation: Composition, physical structure, ground cover and thatch
Vegetation Treatment
Substrates: topography, Slope/Aspect, Soil Type, History of Disturbance

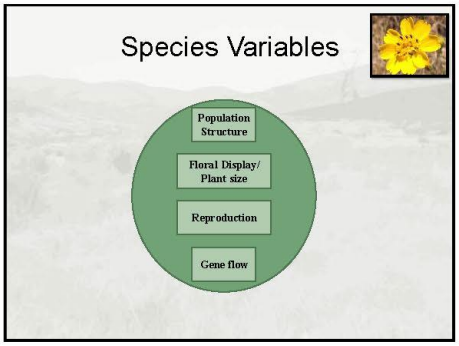

Introduction | Example | Models for Management | Break-Out Groups
Conceptual Models
Bormann et al. 2007. Adaptive Management of Forest Ecosystems: Did Some Rubber Hit the Road? BioScience 57(2)186-191
Increasing reliance on site-specific knowledge and data
10-year report
20-year report
30-year report
Interpret (2000)
Interpret (2010)
Interpret (2020)
Monitor
Plan
Act
FEMAT (1993)
Decreasing reliance on general data and scientists' opinions

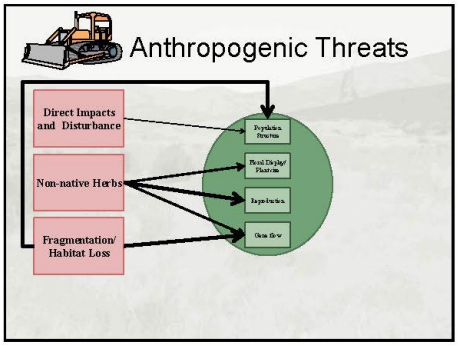

Developing Conceptual Models
Translating Knowledge into Action
Process:
How to Build
a Conceptual Model

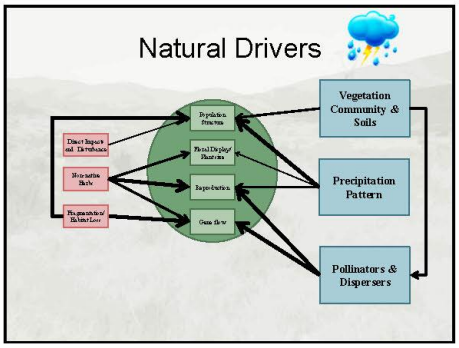

Process
1. Identify the conservation management goal
2. Identify anthropogenic threats
3. Identify natural drivers
4. Identify variables within the species that:
• Evaluate if the goal has been met
• Evaluate the response to management
5. Describe potential management activities and what process they will effect
6. Identify critical uncertainties

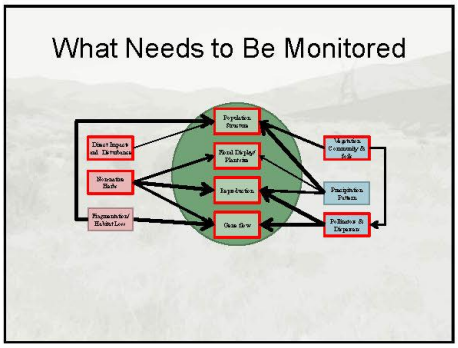

Anatomy of a Conceptual Model
Otay Tarplant
Anthropogenic Drivers
Potential Management
Measurable
Aspects
of
Response
Natural Drivers
Recommended Monitoring
Importance to species

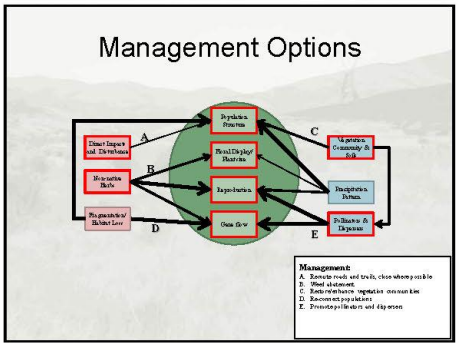

Conservation Goals
Management
Establish sustainable populations of D. conjugens by restoring or enhancing degraded grassland habitat in south county
Monitoring
Monitor restoration and enhancement effectiveness and D. conjugens response

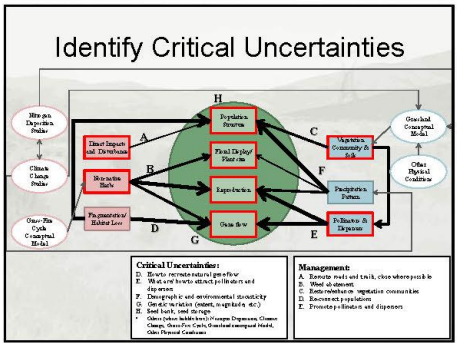

Species Variables
Population Structure
Floral Display/ Plant size
Reproduction
Gene flow

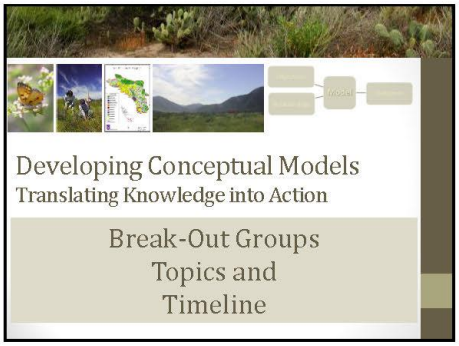

Anthropogenic Threats
Direct Impacts and Disturbance
Non-native Herbs
Fragmentation/ Habitat Loss

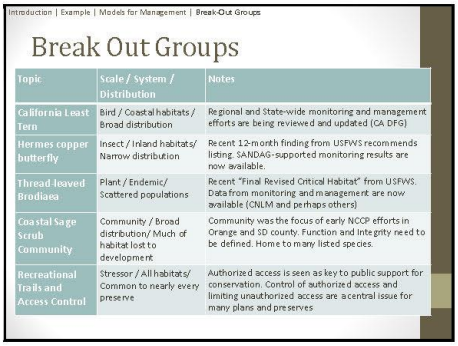

Natural Drivers
Vegetation Community & Soils
Precipitation Pattern
Pollinators & Dispersers

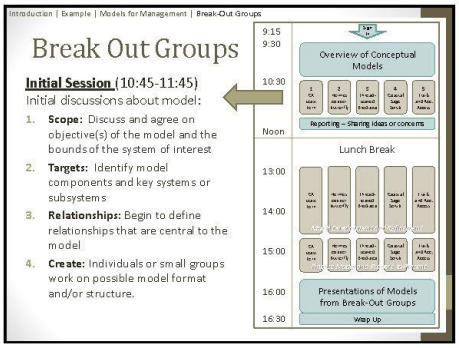

What Needs to Be Monitored

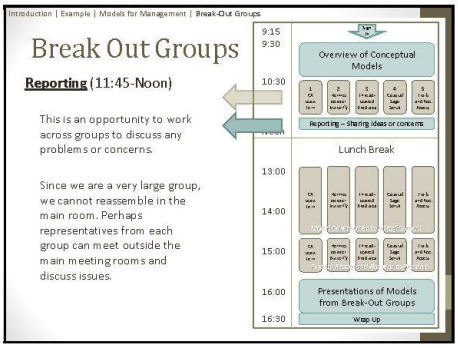

Management Options
Direct Impact and Disturbance
Metapatch Baths
Fragmentation/ Habitat Loss
Population Process
Plant Display Patterns
Repollination
Gene flow
Migration, Community & Soil
Precipitation Patterns
Pollinators & Dispersers
A
B
C
D
E
Management:
A. Reroute roads and trails, close where possible
B. Weed abatement
C. Restore/enhance vegetation communities
D. Reconnect populations
E. Provide pollinators and dispersers

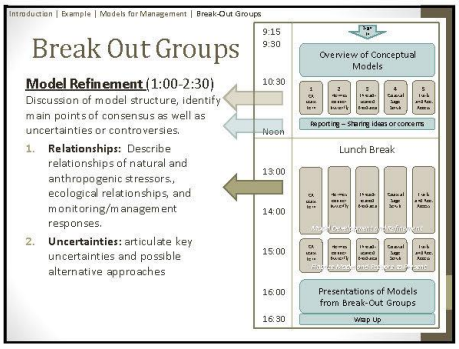

Identify Critical Uncertainties
Nitrogen Deposition Pulse
Climate Change Pulse
Direct Impacts and Disturbance
Metapatch Baths
Fragmentation/ Habitat Loss
Population Process
Plant Display Patterns
Repollination
Gene flow
Migration, Community & Soil
Precipitation Patterns
Pollinators & Dispersers
Grassland Conceptual Model
Other Physical Conditions
A
B
C
D
E
F
G
H
Critical Uncertainties:
Management:
A. Reroute roads and trails, close where possible
B. Weed abatement
C. Restore/enhance vegetation communities
D. Reconnect populations
E. Provide pollinators and dispersers

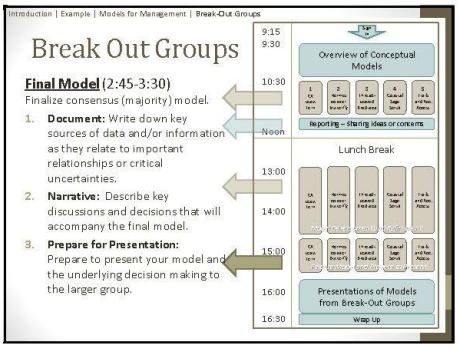

Developing Conceptual Models
Translating Knowledge into Action
Break-Out Groups
Topics and
Timeline

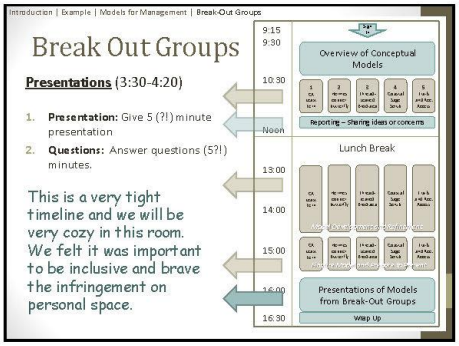

Introduction | Example | Models for Management | Break-Out Groups
Break Out Groups
Topic
Scale / System / Distribution
Notes
California Least Tern
Bird / Coastal habitats / Broad distribution
Regional and State-wide monitoring and management efforts are being reviewed and updated (CA DFG)
Hermes copper butterfly
Insect / Inland habitats/ Narrow distribution
Recent 12-month finding from USFWS recommends listing. SANDAG-supported monitoring results are now available.
Thread-leaved Brodiaea
Plant / Endemic/ Scattered populations
Recent "Final Revised Critical Habitat" from USFWS. Data from monitoring and management are now available (CNLM and perhaps others)
Coastal Sage Scrub Community
Community / Broad distribution/ Much of habitat lost to development
Community was the focus of early NCCP efforts in Orange and SD county. Function and integrity need to be defined. Home to many listed species.
Recreational Trails and Access Control
Stressor / All habitats/ Common to nearly every preserve
Authorized access is seen as key to public support for conservation. Control of authorized access and limiting unauthorized access are a central issue for many plans and preserves

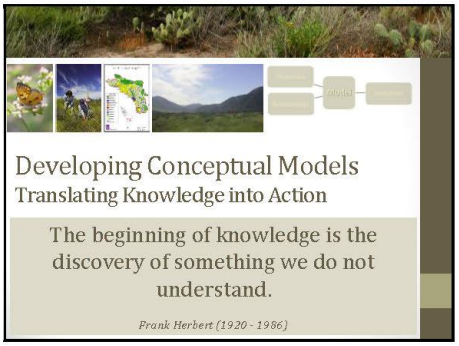

Introduction | Example | Models for Management | Break-Out Groups
Break Out Groups
Initial Session (10:45-11:45)
Initial discussions about model:
1. Scope: Discuss and agree on objective(s) of the model and the bounds of the system of interest
2. Targets: Identify model components and key systems or subsystems
3. Relationships: Begin to define relationships that are central to the model
4. Create: Individuals or small groups work on possible model format and/or structure.
9:15
9:30
10:30
Noon
13:00
14:00
15:00
16:00
16:30
Overview of Conceptual Models
Reporting – Sharing ideas or concerns
Lunch Break
Presentations of Models from Break-Out Groups
Wrap Up


Introduction | Example | Models for Management | Break-Out Groups
Break Out Groups
Reporting (11:45-Noon)
This is an opportunity to work across groups to discuss any problems or concerns.
Since we are a very large group, we cannot reassemble in the main room. Perhaps representatives from each group can meet outside the main meeting rooms and discuss issues.
9:15
9:30
10:30
13:00
14:00
15:00
16:00
16:30
Overview of Conceptual Models
Reporting – Sharing ideas or concerns
Lunch Break
Presentations of Models from Break-Out Groups
Wrap Up


Introduction | Example | Models for Management | Break-Out Groups
Break Out Groups
Model Refinement (1:00-2:30)
Discussion of model structure, identify main points of consensus as well as uncertainties or controversies.
1. Relationships: Describe relationships of natural and anthropogenic stressors, ecological relationships, and monitoring/management responses.
2. Uncertainties: articulate key uncertainties and possible alternative approaches
9:15
9:30
10:30
Noon
13:00
14:00
15:00
16:00
16:30
Overview of Conceptual Models
Reporting – Sharing ideas or concerns
Lunch Break
Presentations of Models from Break-Out Groups
Wrap Up


Introduction | Example | Models for Management | Break-Out Groups
Break Out Groups
Final Model (2:45-3:30)
Finalize consensus (majority) model.
1. Document: Write down key sources of data and/or information as they relate to important relationships or critical uncertainties.
2. Narrative: Describe key discussions and decisions that will accompany the final model.
3. Prepare for Presentation: Prepare to present your model and the underlying decision making to the larger group.
9:15
9:30
10:30
Noon
13:00
14:00
15:00
16:00
16:30
Overview of Conceptual Models
Reporting – Sharing ideas or concerns
Lunch Break
Presentations of Models from Break-Out Groups
Wrap Up


Introduction | Example | Models for Management | Break-Out Groups
Break Out Groups
Presentations (3:30-4:20)
1. Presentation: Give 5 (?!) minute presentation
2. Questions: Answer questions (5?!) minutes.
This is a very tight timeline and we will be very cozy in this room. We felt it was important to be inclusive and brave the infringement on personal space.
9:15
9:30
10:30
Noon
13:00
14:00
15:00
16:00
16:30
Overview of Conceptual Models
Reporting – Sharing ideas or concerns
Lunch Break
Presentations of Models from Break-Out Groups
Wrap Up


Developing Conceptual Models
Translating Knowledge into Action
The beginning of knowledge is the discovery of something we do not understand.
Frank Herbert (1920 - 1986)

APPENDIX 7 – CVS FOR THE THREE EXTERNAL REVIEWERS

Curriculum Vitae
ERICA FLEISHMAN • 19 April 2012

Education
B.S. Biological Sciences. Stanford University, 1991
M.S. Biological Sciences. Stanford University, 1992
Ph.D. Ecology, Evolution, and Conservation Biology. University of Nevada, Reno, 1997

Selected professional appointments
2000 – 2005. Research Associate. Center for Conservation Biology, Stanford University.
2005 – 2006. Senior Research Scientist. Center for Conservation Biology, Stanford University.
2006 – 2009. Director, Conservation and Resource Management Program. National Center for Ecological Analysis and Synthesis, University of California, Santa Barbara.
2009 – . Researcher. Bren School of Environmental Science & Management and Earth Research Institute, University of California, Santa Barbara.
2010 – . Researcher. John Muir Institute of the Environment, University of California, Davis.
2010 – . Editor in Chief, *Conservation Biology*

Selected professional service and activities
1999. Scientific Review Panel, Terrestrial indicators of ecological integrity, U.S. Environmental Protection Agency.
2001 – 2002. Scientific Review Panel, Evaluating potential methods for prioritizing species for listing actions under the Endangered Species Act, U.S. Fish and Wildlife Service.
2002 – 2004. Facilitator, Science Advisory Panel. East Contra Costa County, California Habitat Conservation Plan / Natural Community Conservation Plan.
2003. Consulting Scientist, Wildlife Conservation Society / Foundations of Success. Development of a monitoring and evaluation system and learning network for conservation projects supported by the Doris Duke Charitable Foundation.
2005 – . Associate editor, *Global Ecology and Biogeography*
2007. Science Advisor, California Bay–Delta Conservation Plan.
2009 – . Subject editor, *Ecography*
2010 – . Member, Commission on Ecosystem Management, International Union for Conservation of Nature.
2011. Panel member, Evaluation of biology, health, and medicine in Norway. The Research Council of Norway.
2011 – . Member, committee on ecological risk assessment under the Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA) and Endangered Species Act (ESA), National Research Council.

Selected peer-reviewed publications (of more than 80)
Fleishman, E., R.B. Blair, and D.D. Murphy. 2001. Empirical validation of a method for umbrella species selection. Ecological Applications 11:1489–1501.
Fleishman, E., C. Ray, P. Sjögren-Gulve, C.L. Boggs, and D.D. Murphy. 2002. Assessing the relative roles of patch quality, area, and isolation in predicting metapopulation dynamics. Conservation Biology 16:706–716.
Fleishman, E. and R. Mac Nally. 2003. Distinguishing between signal and noise in faunal responses to environmental change. Global Ecology and Biogeography 12:395–402.
Fleishman, E., R. Mac Nally, and J.P. Fay. 2003. Validation tests of predictive models of butterfly occurrence based on environmental variables. Conservation Biology 17:806–817.

Fleishman, E., R.F. Noss, and B.R. Noon. 2006. Utility and limitations of species richness metrics for conservation planning. Ecological Indicators 6:543–553.
Thomson, J.R., E. Fleishman, R. Mac Nally, and D.S. Dobkin. 2006. Comparison of predictor sets for species richness and the number of rare species of butterflies and birds. Journal of Biogeography 34:90–101.
Fleishman, E. and R. Mac Nally. 2007. Measuring the response of animals to contemporary drivers of fragmentation. Invited paper. Canadian Journal of Zoology 85:1080–1090.
Mac Nally, R., E. Fleishman, J.R. Thomson, and D.S. Dobkin. 2008. Use of guilds for modeling avian responses to vegetation in the Intermountain West (U.S.A.). Global Ecology and Biogeography 17:758–769.
Fleishman, E. and D.D. Murphy. 2009. A realistic assessment of the indicator potential of butterflies and other charismatic taxonomic groups. Conservation Biology 23:1109–1116.
Thomson, J.R., W.J. Kimmerer, L.R. Brown, K.B. Newman, R. Mac Nally, W.A. Bennett, F. Feyrer, and E. Fleishman. 2010. Bayesian change point analysis of abundance trends for pelagic fishes in the upper San Francisco Estuary. Ecological Applications 20:1431–1448.
Fleishman, E., D.E. Blockstein, J.A. Hall, M.B. Mascia, M.A. Rudd, J.M. Scott, W.J. Sutherland, A.M. Bartuska, A.G. Brown, C.A. Christen, J. Clement, D. DellaSala, C.D. Duke, M. Eaton, S.J. Fiske, H. Gosnell, J.C. Haney, M. Hutchins, M.L. Klein, J. Marqusee, B.R. Noon, P. Orbuch, J. Powell, S.P. Quarles, K.A. Saterson, C. Savitt, B.A. Stein, M.S. Webster, and A. Vedder. 2011. Top 40 priorities for science to inform conservation and management policy in the United States. BioScience 61:290–300.
Sutherland, W.J., E. Fleishman, M.B. Mascia, J. Pretty, and M.A. Rudd. 2011. Methods for collaboratively identifying research priorities and emerging issues in science and policy. Methods in Ecology and Evolution 2:238–247.
Scholz, N.L, E. Fleishman, L.R. Brown, I. Werner, M.L. Johnson, M.L. Brooks, C.L. Mitchelmore, and D. Schlenk. 2012 A perspective on modern pesticides, pelagic fish declines, and unknown ecological resilience in highly managed ecosystems. BioScience, in press.

Selected grants and awards

2003 – 2005. Mac Nally, R. and E. Fleishman. Reconstructing landscapes for biodiversity: from predictive modelling to future scenarios. Australian Research Council (Grant No. DP0343898). AU$300,000.
2009 – 2011. Determining priorities for conservation science and policy in the face of climate change. Kresge Foundation. $176,073.
2009 – 2011. Mac Nally, R. and E. Fleishman. Change ecology – gaining broadscale, timely biodiversity knowledge in a time of uncertainty. Australian Research Council (Grant No. DP0984170). AU$440,000.
2009 – 2011. Maintaining connectivity in the Great Basin in the face of climate and land-cover change. Wilburforce Foundation. $50,000.
2009 – 2012. Fleishman, E., J.C. Chambers, D.S. Dobkin, and B.G. Dickson. Decision support tools for conserving Greater Sage-Grouse during fire and fuels management projects in pinyon and juniper woodlands. Joint Fire Science Program. $300,464.
2009 – 2011. Cumulative effects of underwater anthropogenic sound on marine mammals. BP Exploration. $266,000.
2012 – 2016. Synthesis and communication of results from the evaluation of a pelagic organism decline (POD) in the upper San Francisco Estuary. U.S. Fish and Wildlife Service. $435,000.
2012 – 2016. Fleishman, E., B.G. Dickson, D.S. Dobkin, M. Leu, and B.R. Noon. Methods for assessment of species richness and occupancy across space, time, taxonomic groups, and ecoregions. Strategic Environmental Research and Development Program. $2,100,160.

Curtis H. Flather

U.S. Forest Service, Rocky Mountain Research Station
2150 Centre Ave., Bldg A, Fort Collins, CO 80526
970-295-5910 (voice); cflather@fs.fed.us

Professional Preparation

University of Vermont	Wildlife Biology	B.S.	1979
Colorado State University	Wildlife Biology	M.S.	1982
Colorado State University	Wildlife Biology	Ph.D.	1992

Appointments

Research Wildlife Biologist, US Forest Service, Rocky Mountain Research Station, 1981-Present.

Research Interests

Extend the scientific basis for ecosystem management in a manner that maintains the character (structure and processes) of ecosystems while providing for human benefits derived from ecosystem services. My specific research interests under this broad objective are four fold: (1) Improve our understanding of how habitats, populations, and communities respond to changes in land use, disturbance, and climate; (2) Develop and test cartographic-based approaches to biodiversity assessments; (3) Extend conservation scientists' ability to design landscapes to provide for multiple benefits; and (4) Document trends in wildlife resources for land use policy.

Invited presentations (selected examples)

Flather, C.H., and M.H. Mockrin. 2011. Wildlife resource status and trends for a national assessment: futuring games with disparate economic and ecological data. 21 April 2011. Interactions of Society and the Environment Seminar Series . USFS, USGS. Fort Collins, CO.

Shifley, S.R., **C.H. Flather**, W.B. Smith, K.H. Riitters, and C.H. Sieg. 2010. Status and progress in large-scale assessment of biological diversity in the United States. XXIII IUFRO World Congress. 23-28 August 2010. Seol, South Korea.

Flather, C. H., G. D. Hayward, and L. A. Joyce. 2009. The changing face of wildlife management on National Forests and Grasslands: initial attempts to address climate change in the U.S. Forest Service. 16th Annual Conference, The Wildlife Society. 20-24 September 2009. Monterey, CA

Flather, C. H., J. A. Tracy, B. R. Noon, R. Sheffield, and M. S. Knowles. 2008. Searching for where to search: sifting forest inventories for Singer tracts. Ivory-billed Woodpecker Science Symposium. 10-12 June 2008. Lafayette, LA.

Flather, C. H., Shriner, S. A., K. R. Wilson, G. C. Reese, and L. J. O'Gan. 2005. Where to conserve biodiversity: does map error affect our choice? Presented in "Overview and Treatment of Spatial Errors in GIS Applications" symposium. Annual Conference of The Wildlife Society. 25-29 September 2005. Madison, WI.

Flather, C. H., and M. Bevers. 2003. Habitat amount and species persistence – a search for theoretical synthesis. Presented in "Habitat Quality, Size, and Configuration and its Role in Population Viability." International Association for Landscape Ecology, 6th World Congress. 13-17 July 2003. Darwin, Australia.

Noon, B., and **C. Flather**. 2003. An optimal mix of coarse and fine-filter elements to conserve biological diversity. Symposium paper presented at: "Innovations in Species Conservation: Integrative Approaches to Address Rarity and Risk." 28-30 April 2003. Portland, OR.

Publications (selected examples)

Flather, C. H., G. D. Hayward, S. R. Beissinger, and P. A. Stephens. 2011. Minimum viable populations: is there a magic number for conservation practitioners? ***Trends in Ecology and Evolution*** 26:307-316.

Hansen, A. J., L. B. Phillips, **C. H. Flather**, and J. Robison-Cox. 2011. Carrying capacity for species richness as a context for conservation: a case study on North American breeding birds. ***Global Ecology and Biogeography*** 20:817-831.

Gutzwiller, K. J., and **C. H. Flather**. 2011. Wetland features and landscape context predict the risk of wetland habitat loss. ***Ecological Applications*** 21:968-982.

Radeloff, V.C., S. I. Stewart, T.J. Hawbaker, U. Gimmi, A.M. Pidgeon, **C.H. Flather**, R. B. Hammer, and D. P. Helmers. 2010. Housing growth in and near United States protected areas limits their conservation value. ***Proceedings of the National Academy of Sciences*** 107:940-945.

Flather, C. H., K. R. Wilson, S. A. Shriner. 2009. Geographic approaches to biodiversity conservation: implications of scale and error to landscape planning. Pages 85-121. *In* J. J. Millspaugh and F. R. Thompson, III, eds. Models for planning wildlife conservation in large landscapes. Elsevier Science.

Robles, M. D., **C. H. Flather**, S. M. Stein, M. D. Nelson, and A. Cutko. 2008. The geography of private forests that support at-risk species in the coterminous United States. ***Frontiers in Ecology and the Environment*** 6:301-307.

Flather, C. H., and C. H. Sieg. 2007. Species rarity: definition, causes, and classification. Pages 40-66. In: M. G. Raphael and R. Molina (eds). Conservation of rare or little-known species: biological, social, and economic considerations. Island Press, Washington, DC.

Shriner, S. A., K. R. Wilson, **C. H. Flather**. 2006. Reserve networks based on richness hotspots and representation vary with scale. ***Ecological Applications*** 16:1660-1673.

Bender, D. J., **C. H. Flather**, K. R. Wilson, and G. C. Reese. 2005. Regional data to support biodiversity assessments: terrestrial vertebrate and butterfly data from the Southwest. General Technical Report RMRS-GTR-152. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station. 42 p. +DVD

Vance, M. D., L. Fahrig, and **C. H. Flather**. 2003. Effect of reproductive rate on minimum habitat requirements of forest-breeding birds. ***Ecology*** 84:2643-2653.

Flather, C. H., and M. Bevers. 2002. Patchy reaction-diffusion and population abundance: the relative importance of habitat amount and arrangement. ***American Naturalist*** 159:40-56.

Flather, C. H., M. Bevers, and J. Hof. 2002. Prescribing habitat layouts: analysis of optimal placement for landscape planning. Pages 428-453 *in* K. J. Gutzwiller (ed). *Applying Landscape Ecology in Biological Conservation.* Springer-Verlag, New York. 518pp.

Hansen. A. J., R. P. Nielson, V. Dale, **C. H. Flather**, L. Iverson, D. J. Currie, S. Shafer, R. Cook, and P. J. Bartlein. 2001. Global change in forests: responses of species, communities, and biomes. ***BioScience*** 51:765-779.

Cook, R., **C. H. Flather**, and K. W. Wilson. 2000. Faunal characteristics of the Southern Rocky Mountains of New Mexico: implications for biodiversity analysis and assessment. General Technical Report

RMRS-GTR-58. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station.

Synergistic Activities

Wildlife and Fish Resource Specialist for U.S. Forest Service. Team leader for completing decadal national assessments of wildlife resources on all land ownerships.

Domestic grazing impacts on biodiversity in the southwestern U.S. Team member involved in developing species locational databases for vertebrates and butterflies.

Biodiversity Subcommittee of the Forest Sector for the National Climate Change Assessment. Team member evaluating the likely impacts of global change on land use, species richness, and threatened and endangered species.

Service on editorial boards for ***Landscape Ecology*** (1/04 – 4/07), ***American Naturalist*** (1/02 – 2/05), ***Environmental Management*** (1/00 – 12/03), and ***Wildlife Society Bulletin*** (11/90 – 2/93).

Research Support (selected examples)

$812,000 March 2011 – 2015. The Effects of Extreme Climate Events on Avian Demographics: the Role of Habitat Refugia in Mitigating Climate Change. Funding Agency: NASA. I serve as a Co-PI.

$603,400 April 2007 – Present. Effects of Fire, Extreme Weather, and Anthropogenic Disturbance on Avian Biodiversity in the United States. Funding Agency: NASA. I serve as a Co-PI.

$162,000 November 2006 – 2008. Synthesis and analysis of wildlife habitat response to climate change: implications to the implementation of State Wildlife Action Plans. Funding Agency: National Council for Science and the Environment ($105K); USDA, Forest Service ($57K). PIs: Linda Joyce and Curtis Flather.

$70,000 July 2006-2009. Analysis of rangewide habitat availability for the Ivory-billed Woodpecker. Funding agencies: US, Fish and Wildlife Service (40K); USDA, Forest Service (5K); and postdoctoral fellowship (25K) supported by an NSF grant to CSU. Co-PI: Dr Barry Noon, Colorado State University.

$57,000 June 2005-December 2007. Wetland persistence and transition in the southeastern U.S. in relation to wetland features and surrounding landscape conditions. Funding agency: USDA, Forest Service, RPA staff. Co-PI: Dr. Kevin Gutzwiller, Baylor University.

$322,000 October 2001-January 2005. Using biological databases to improve biodiversity assessments: new methods for geographic-based analysis. Funding agencies: NSF and USDA, Forest Service, Region3. NSF grant awarded to Colorado State University. PI: Dr. Kenneth Wilson. I served as Co-PI.

$320,000 June 1998-2003. Paired ecosystem study of oak woodland dynamics in Israel and California. Funding agencies: Jewish National Fund, Arid Lands Consortium; USDA, Forest Service, Inventory and Monitoring Institute. Co-PIs: Dr. Yohay Carmel, The Technion - Israel Institute of Technology, Haifa, Israel; Dr. Denis Dean, Colorado State University, Fort Collins, CO.

Sharon K. Collinge
Department of Ecology & Evolutionary Biology and Environmental Studies Program
334 UCB, University of Colorado, Boulder, CO 80309-0334
303-735-3242 (voice); 303-492-8699 (FAX); sharon.collinge@colorado.edu

Professional Preparation

Kansas State University	Biology	B.A., 1985
University of Nebraska	Biology	M.S., 1987
Harvard University	Landscape Ecology	Ph.D., 1995

Academic and Professional Appointments

2010-*present*	Professor, Joint appointment with Department of Ecology & Evolutionary Biology and Environmental Studies Program, University of Colorado
2003-2010	Associate Professor, Joint appointment with Department of Ecology & Evolutionary Biology and Environmental Studies Program, University of Colorado
1998-2003	Assistant Professor, Joint appointment with Department of Ecology & Evolutionary Biology and Environmental Studies Program, University of Colorado
1996-1998	Assistant Professor, Department of Environmental Design, UC-Davis
1990-1995	Teaching Fellow, Department of Environmental Studies and Public Policy and Graduate School of Design, Harvard University

Areas of expertise

My scholarship and teaching emphasize understanding the ecological consequences of human-induced changes to natural systems. My research centers on the impacts of habitat loss, fragmentation, and restoration on the persistence of native species. My current research focuses specifically on the use of ecological theory to guide efforts to restore vernal pool ecosystems that have been degraded by human activities. I am particularly interested in the interface between environmental science and policy regarding endangered species and habitat protection.

Selected publications (see Research: Publications tab at www.collingelab.com for full list)

Books and edited volumes

Collinge, S.K. 2009. *Ecology of fragmented landscapes*. Johns Hopkins University Press, Baltimore, Maryland, USA.

Limerick, P.N., A. Cowell, and S.K. Collinge. (Editors). 2009. *Remedies for a New West: Healing Landscapes, Histories, and Cultures*. University of Arizona Press, Tucson, AZ.

Collinge, S.K. and C. Ray (Editors). 2006. *Disease ecology: community structure and pathogen dynamics*. Oxford University Press, Oxford, UK.

Collinge, S.K. (Editor). 2001. *Special Issue: Spatial ecology and biological conservation. Biological Conservation* 100(1): 1-150.

Peer-reviewed journal articles and book chapters

(1) Vernal pools

Collinge, S.K., C. Ray, and F. Gerhardt. 2011. Long-term data on vernal pool plant communities reveal formerly cryptic effects of biotic resistance to exotic species invasion. *Ecological Applications* 21:2105-2118.

Collinge, S.K. and C. Ray. 2009. Transient patterns in the assembly of vernal pool plant communities. *Ecology* 90(12):3313-3323.

Ramp, J.M., T.A. Ranker, and S.K. Collinge. 2008. Conservation of rare species with an island-like distribution: a case study of *Lasthenia conjugens* (Asteraceae) using population genetic structure and distribution of rare markers. *Plant Species Biology* 23:97-110.

Gerhardt, F. and S.K. Collinge. 2007. Abiotic constraints eclipse biotic resistance in determine invasibility along experimental vernal pool gradients. *Ecological Applications* 17:922-933.

Ramp, Jennifer M., Tom A. Ranker, and Sharon K. Collinge. 2006. Restoration genetics of the vernal pool endemic *Lasthenia conjugens* (Asteraceae). *Conservation Genetics* 7:631-649.

Gerhardt, F. and S.K. Collinge. 2003. Exotic plant invasions of vernal pools in the Central Valley of California, USA. *Journal of Biogeography* 30:1043-1052.

(2) Disease ecology

Brinkerhoff, R. Jory, A.P. Martin, R.T. Jones, and S.K. Collinge. 2011. Population genetic structure of the prairie dog flea and plague vector, *Oropsylla hirsuta*. *Parasitology* 138:71-79.

Brinkerhoff, R.J., S.K. Collinge, C. Ray, and KL. Gage. 2010. Rodent and flea abundance fail to predict a plague epizootic in black-tailed prairie dogs. *Vector-Borne and Zoonotic Diseases* 10(1):47-52.

Cully, J.F., Jr., T.L. Johnson, S.K. Collinge, and C. Ray. 2010. Disease limits populations: plague and black-tailed prairie dogs. *Vector-Borne and Zoonotic Diseases* 10(1):7-15.

Cully, J.F., Jr., S.K. Collinge, W.C. Johnson, C. Ray, B. Thiagarajan, D.B. Conlin, and B. Holmes. 2010. Spatial variation in keystone effects: small mammal diversity associated with black-tailed prairie dog colonies. *Ecography* 33:667-677.

Bai, Y., M.Y. Kosoy, C.H. Calisher, J.F. Cully, Jr., and S.K. Collinge. 2009. Effects of rodent community diversity and composition on prevalence of an endemic bacterial pathogen – *Bartonella*. *Biodiversity* 10(4):3-11.

Brinkerhoff, R.J., C. Ray, B. Thiagarajan, S.K. Collinge, J.F. Cully, Jr, B. Holmes and K.L. Gage. 2008. Prairie dog presence affects occurrence patterns of disease vectors on small mammals. *Ecography* 31:654-662.

Collinge, S.K., W.C. Johnson, C. Ray, R. Matchett, J. Grensten, J.F. Cully, Jr., K.L. Gage, M.Y. Kosoy, J.E. Loye, and A.P. Martin. 2005a. Landscape structure and plague occurrence in black-tailed prairie dogs. *Landscape Ecology* 20:941-955.

Collinge, S.K., W.C. Johnson, C. Ray, R. Matchett, J. Grensten, J.F. Cully, Jr., K.L. Gage, M.Y. Kosoy, J.E. Loye, and A.P. Martin. 2005b. Testing the generality of a trophic-cascade model for plague. *EcoHealth* 2:102-112.

Johnson, W.C. and S.K. Collinge. 2004. Landscape effects on black-tailed prairie dog colonies. *Biological Conservation* 115:487-497.

Externally funded research grants: current and recent

National Science Foundation, Long-term research in environmental biology (LTREB) program, "Evaluating the role of metacommunity dynamics in the assembly of vernal pool plant communities," 2008-2013, $450,000, PI

National Science Foundation, Ecology of Infectious Diseases program, "Landscape effects on disease dynamics in prairie dogs," 2002-2007, $1,776,000 (Project Director, with 7 collaborators), Supplemental funding 2005-2007, $56,715

U.S. Environmental Protection Agency Office of Research and Development, STAR Program in Wildlife Risk Assessment, "Habitat alteration and disease effects on black-tailed prairie dogs," 2001-2005, $500,000 (Project Director, with 6 collaborators)

Teaching activities

Undergraduate courses

Food and the Environment: ENVS 4120: 3-unit lecture and discussion course
General Biology: EBIO 1220 (3-units, co-taught with Pieter Johnson)
Conservation Biology: EBIO/ENVS 3040: 4-unit lecture and recitation course
Critical thinking in Environmental Studies: ENVS 4800: Conservation biology and planning

Graduate courses

Environmental Science: ENVS 5002 (3-units)
Graduate seminar in Restoration Ecology: EBIO 6100 (3-units)
Graduate seminar in Conservation Biology: EBIO 6100 (2-units)