Monitoring and Management in the San Diego Multiple Species Conservation Program: Results from a Structured Workshop

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EXECUTIVE SUMMARY

The goal of this report is to summarize the results from a structured workshop (modeled after a Dahlem conference) focused on identifying ways to improve monitoring and management of regional conservation plans in San Diego County. This report summarizes the collaborative efforts of a diverse group of stakeholders who participated in this workshop. The structure of the workshop was designed to identify areas of consensus, discuss areas of disagreement, and to prioritize next steps that will ultimately lead to improved monitoring and management of Multiple Species Conservation Program (MSCP) lands. This report is intended to be a working document that will inform and improve monitoring and management efforts. It is our hope that the report will be of use to a wide range of readers.

The foreword written by Susan Wynn (Biologist, USFWS) describes the history of implementation of the monitoring and management efforts following the adoption of the MSCP in 1998. During the initial years of implementation, it became apparent that the data collected using the Biological Monitoring Plan (BMP, Ogden 1996) protocols would not answer many of the key questions associated with the performance of the preserve system. As a result, the MSCP stakeholders (Wildlife Agencies, permittees and other interested parties) began to develop and refine new approaches to monitoring and adaptive management. A series of reports were written by a variety of experts with each document building on the previous documents. The key points of these documents included: (1) the need to connect monitoring data to management at the preserve level and the region; (2) the benefit of using conceptual models that related stressors and threats to key species and communities for focusing monitoring and management efforts; (3) the need to improve the utility of monitoring protocols so that they can inform management actions; (4) the need to prioritize funding for monitoring and management; and (5) the need to develop, test, and refine monitoring protocols as an ongoing process. Wynn concludes that the stakeholders generally agree with the conclusions found in these reports; however there is no consensus on how to implement these recommendations. The Dahlem conference provided a forum to discuss these topics and strategize on next steps for the management and monitoring of the regional plans in San Diego County.

Implementation of a cost-effective and rigorous monitoring and management program for a multiple-species HCP/NCCP is challenging. Ecological systems like those conserved under the MSCP are difficult to monitor and manage because they are inherently complex and variable across space and through time. Management of these systems is difficult because of the number of agencies and personnel involved in decision making and management activities. This workshop provided a collaborative forum to address some of the key scientific and organizational challenges facing the San Diego MSCP but is relevant to any multiple species conservation program in the region and throughout the state. The workshop focused on three main topics, each exploring different challenges in the effective monitoring and management of multi-species, multi-jurisdictional conservation plans. These included 1) how to effectively address different spatial and temporal scales, 2) how to prioritize and coordinate among numerous species and organizational levels, and 3) how to overcome impediments and develop solutions for coordination and implementation of successful monitoring and management programs.

Group 1 identified key issues and challenges that arise when monitoring and management crosses various jurisdictional boundaries and a number of spatial and temporal scales. They recommend that monitoring and management efforts be driven by the spatial scale of species and habitats rather than jurisdictional boundaries, and that tracking population trends and distribution patterns should occur over a long time frame. Monitoring programs must also track threats and stressors that drive population and ecosystem changes. Effective monitoring can be aided by the development of conceptual models showing hypothesized relationships between threats and drivers and the population dynamics of covered species and plant communities. Case studies of the California gnatcatcher, *Arundo donax*, and Tecate cypress are included to illustrate many of the elements discussed in this section.

Group 2 more closely examined the tension between single species monitoring and habitat or ecosystem-level monitoring. They recommended that prioritization of different community elements should be based on: the ability to address MSCP goals and objectives and answer key management questions, species "threatened-ness," the ability of land managers to affect change, and the ability to extract information based on a few measurable factors (i.e., use of indicators). Although single-species monitoring is narrow in scope, it can be productive and integrate well with management programs when conducted in a more predictive framework, with well-defined goals and objectives and an adaptive approach. In addition to monitoring prioritized species directly, a wide variety of indicators can provide a good platform for gauging the status or trend of a broader system. Good indicators should have an explicit link with variables of management interest and generate the appropriate quality of information at a minimal cost. Possible indicators for the San Diego MSCP include remote-sensing based indicators and indices of biological integrity for specific communities or taxa. A number of issues and considerations for using indicators in the San Diego MSCP are discussed. Group 2 also emphasized the need for continual feedback among monitoring, data analysis, and management actions and the importance of sharing results among the various stakeholders involved in the MSCP.

Group 3 identified important issues and impediments to effective cooperation within the MSCP and discussed possible ways to incentivize participation in collaborative planning and management networks. High priority yet readily solvable impediments included: the lack of an approved strategic plan and centralized database, funding allocation challenges, and poorly defined roles and responsibilities of participants. Identified needs and recommended next steps for each of these impediments were outlined. Other lower priority or less tractable impediments also were identified but not discussed in as much detail. Finally, Group 3 developed a conceptual model that illustrated one possible strategy for overcoming or minimizing the major impediments.

In the afterword to the report, Keith Greer (Senior Regional Planner, SANDAG) acknowledges that the integration of science into management for efficient decision making still remains a challenge; but one that is being addressed with a renewed vigor. She mentions that this current workshop had two significant advantages over previous efforts. First, this workshop was able to draw from pilot monitoring efforts and existing regional collaborations that have developed during the implementation of the regional conservation plans. Second, current efforts may be able to draw from a multi-year secure funding source to assist with regional management and monitoring efforts – the *TransNet* Environmental Mitigation Program (EMP).

Greer describes how SANDAG has allocated nearly $19 million dollars toward these efforts. One major result has been the establishment of the San Diego Management and Monitoring Program (SDMMP) to facilitate communication among land managers, promote best management practices, and help to prioritize regional management and monitoring needs. SDMMP is funded to complete the region's first regional Management Strategic Plan which will identify regional goals and objectives at the regional and local management scale, identify key stressors, develop a ranking schema to help inform land managers, and address the level and scale of biological monitoring. In addition, the San Diego State Institute for Ecological Monitoring and Management (IEMM) has been contracted to develop a standardized approach that incorporates science into local land management plans. These two efforts will help address the prevailing theme of the 2010 Dahlem workshop regarding prioritization, scale and standardization.

Keith Greer's afterword reminds us that this report is a working document intended to inform and improve ongoing monitoring and management efforts like the SDMMP's Management Strategic Plan and IEMM's work on improving local land management plans. The report is a step in the adaptive management process. This process is iterative and this report benefits from the earlier efforts described by Susan Wynn in the foreword. Moreover, we expect that this report will be supplanted by other reports in the future as our monitoring and management efforts become more effective and efficient.

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FOREWORD

Susan Wynn, Biologist, US Fish and Wildlife Service

With the execution of the City of San Diego's Multiple Species Conservation Program Implementing Agreement in 1997 by the U. S. Fish and Wildlife Service (FWS), the California Department of Fish and Game (DFG) (collectively the Wildlife Agencies), and the City of San Diego, an innovative partnership to establish and manage an extensive interconnected preserve[1] system was created. The 172,000 plus preserve system in southwestern San Diego County was designed to conserve a diverse array of natural communities, ecosystem functions and a wide variety of species, including the 85 species specifically named on the State and Federal permits for the Multiple Species Conservation Program (MSCP). The MSCP and IAs requires the implementation (at a jurisdiction level) of a biological monitoring plan (hereafter "BMP"; Ogden 1996) for species and habitats and the submittal of biological monitoring reports annually to the Wildlife Agencies by the participating jurisdictions. The MSCP anticipated that the monitoring program of these plans would evolve over time and provided the authority for the Wildlife Agencies, in collaboration with the permittees, to make changes in monitoring protocols and priorities.

The stakeholders, permittees, and the Wildlife Agencies have worked cooperatively on the implementation and refinement of the monitoring program for MSCP. As a result of this cooperative effort, the monitoring program has evolved as expected, with changes occurring to all aspects of the program, from data collection to analysis and storage. The history of this evolution is important in order to understand and appreciate the results/recommendations of the Dahlem workshop.

During the initial years of implementation, the permittees implemented portions of the BMP (Ogden 1996) that was prepared in conjunction with the MSCP. As the initial data was gathered, it became apparent that the data collected using the BMP protocols would not answer many of the key questions associated with the performance of the preserve system for Covered Species nor would it be very useful for informing adaptive management decisions. As a result, the MSCP stakeholders (Wildlife Agencies, permittees and other interested parties) concluded that monitoring and preserve management issues needed additional direction and analysis.

The development and refinement of new approaches to monitoring and adaptive management was done in a stepwise progression, with each document building on the previous documents. These documents were subject to extensive review including that of the Wildlife Agencies. DFG provided much of the funding through local assistance grants to accomplish this effort. The documents were written by a variety of experts including scientists from the U.S. Geological Survey, San Diego State University and the FWS. All documents are posted on the DFG website (http://dfg.ca.gov/) and summarized below.

Designing Monitoring Programs in an Adaptive Management Context for Regional Multiple Species Conservation Plans (Atkinson et al. 2004)

Atkinson et al. (2004) provides a step-by-step procedure for developing effective monitoring programs in an adaptive management context. The guidance takes in to account the specific requirements of NCCP/HCP regional conservation plans. In particular, it integrates monitoring species "covered" by the plan with monitoring ecological integrity and incorporates an adaptive management approach.

[1] The preserve includes multiple large core habitat areas connected by habitat linkages.

Assessment of the Biological Monitoring Plan for San Diego's Multiple Species Conservation Program (Hierl et al. 2005)
Hierl et al. (2005) evaluates the current status of the MSCP monitoring plan and its implementation. The document discusses how the MSCP is consistent (or not) with the 9 steps outlined in Atkinson et al and then makes recommendations for MSCP relative to each of the 9 steps.

San Diego Multiple Species Conservation Program Species Prioritizations (Regan et al. 2006)
Regan et al. (2006) applied a step-down approach to the list of MSCP covered species in order to prioritize them for monitoring consideration. Each species was categorized based on their at-risk classification; the threats/risk factors facing the species were identified and ranked; the temporal response of species to the threats was identified as short-term or long-term; and the habitat associations used by the species and their general spatial distribution in the County (e.g., widespread but sparse) were described. Once the species list had been prioritized, they made recommendations on how to develop a regional monitoring strategy.

Grouping and Prioritizing Natural Communities for the San Diego Multiple Species Conservation Program (Franklin et al. 2006)
Franklin et al 2006 assessed the current composition and distribution of landscape components in the MSCP, and then prioritized the natural communities for monitoring based on an analysis of representativeness, extent, fragmentation, endangerment and threats. Aggregated communities that received high priority rankings based on several criteria included coastal sage scrub, meadows, and freshwater wetlands. Other communities with high endangerment or threats include: Southern foredunes, Southern coastal salt marsh, Southern coastal bluff scrub, Maritime succulent scrub, Diegan coastal sage scrub, Southern maritime chaparral, Valley needlegrass grassland, Cismontane alkali marsh, Southern arroyo willow riparian forest, Southern willow scrub, Engelmann oak woodland, Torrey Pine forest, and Tecate Cypress forest.

San Diego Multiple Species Program (MSCP) Rare Plant Monitoring Review and Revision (McEachern et al. 2006)
McEachern et al. (2006) reviewed the current status of the rare plant monitoring within MSCP and provide recommendations for revised rare plant monitoring framework that focuses on the assessment of how populations of MSCP taxa respond to management regimes and particular management actions.

Developing Conceptual Models to Improve the Biological Monitoring Plan for San Diego's Multiple Species Conservation Plan (Hierl et al. 2007)
Hierl et al. (2007) presents a framework for developing conceptual models for the MSCP Monitoring Program. They recommend four major steps in identifying the parameters and elements to be monitored.

Draft San Diego Multiple Species Conservation Program Animals Species Monitoring Protocols (Winchell et al. 2008)
Winchell et al. (2008) developed monitoring protocols for the priority one species (as defined above in Regan et. al.) The protocols begin by asking questions, delineating specific monitoring objectives, and then determining an appropriate monitoring protocol to address the question(s) of interest. Each protocol's target inference is clearly stated, followed by a description of a sampling procedure designed to provide the desired level of inference. The analysis procedures are selected prior to data collection.

The key points from the documents are:

- Monitoring data should be integrally connected to management at both the preserve level and the regional preserve system level (Atkinson et al. 2004)
- Conceptual models (e.g., stressors and threats on covered species) are important to help focus both monitoring and management (Atkinson et al. 2004, Hierl et al. 2005)
- Existing data sets collected prior to the Draft San Diego Multiple Species Conservation Program Animals Species Monitoring Protocols (Winchell et al. 2008) have significant problems (lack of metadata, poor statistical power, small sample frame, protocols have varied over time) and often can only be utilized to show where a species is present rather than status and trend of the species or for informing or evaluating management actions (Hierl et al. 2005)
- Analysis of the monitoring data has been inconsistent and/or lacking (Hierl et al. 2005)
- Since funding for monitoring and management is limited, what is done should be based on a set of priorities (Risk Groups, etc.) (Atkinson et al. 2004, Regan et al. 2006)
- Revised monitoring protocols should be developed, tested, evaluated and modified as needed (Atkinson et al. 2004, Winchell et al. 2008)

The stakeholders generally agree with the conclusions found in these reports; however there is no consensus on how to implement these recommendations. The Dahlem conference provided a forum to discuss these topics and strategize on next steps for the management and monitoring of the regional plans in San Diego County. The following document summarizes the results of the Dahlem conference.

ACKNOWLEDGEMENTS

Douglas Deutschman and Spring Strahm, San Diego State University

The workshop and subsequent report were funded by SANDAG through the Environmental Mitigation Program (EMP) of *TransNet*. We thank the members of the EMP Working Group for their support and guidance. The workshop benefitted from the tremendous efforts of Keith Greer, Senior Regional Planner at SANDAG and Ron Rempel, Director of the San Diego Management and Monitoring program. This project would not have been possible without their guidance, knowledge and experience.

The topics for the workshop were refined by an ad hoc steering committee. We held several formal and informal meetings in the summer of 2010. We thank (in alphabetical order) Keith Greer, Mike Grim, Brenda Johnson, Barb Kus, Ron Rempel, Trish Smith, Jill Terp, and Clark Winchell.

This report reflects the combined efforts of many individuals. This report is a synthesis of input, writing, and comments from the workshop participants. The report would not have been possible without their expertise and time. Participants were (in alphabetical order): Jeff Crooks, Jay Diffendorfer, Patricia Gordon-Reedy, Keith Greer, Mike Grim, Brenda Johnson, Barb Kus, Rebecca Lewison, John Martin, Dave Mayer, Nicole McGinnis, Betsy Miller, Karen Miner, Tom Oberbauer, Mark Pavelka, Kris Preston, Ron Rempel, Joyce Schlachter, Trish Smith, Markus Spiegelberg, Doug Stow, Ron Swaisgood, Jill Terp, Winston Vickers, Clark Winchell, and Susan Wynn.

Finally, we want to acknowledge that this report was not written by committee. In fact it was written by three committees. The document’s main strength is the wealth of expertise that was represented in the three working groups. On the other hand, this approach meant that editing the document to improve overall organization and flow was challenging. As editors, we tried to streamline and synthesize the chapters into a coherent document. This task was difficult and we apologize to the authors for any inadvertent errors and/or omissions.

Douglas Deutschman and Spring Strahm

WORKSHOP STRUCTURE

San Diego's Multiple Species Conservation Program (MSCP) intends to conserve 85 specific "covered" species as well as the diversity and function of intact ecosystems through preservation and adaptive management. Responsibility for monitoring and management of this large network of conserved lands lies with multiple organizations and jurisdictions but fall primarily to the County and City of San Diego, the U.S. Fish and Wildlife Service (USFWS) and California Department of Fish and Game (CDFG). Although the plan was approved more than 10 years ago, there is no consensus on how to prioritize, coordinate, and implement monitoring and management on these lands.

Ecological systems like the MSCP reserve network are difficult to monitor and manage because they are inherently complex and extremely variable across space and through time. The challenge of managing of these systems is further complicated by the wide array of agencies, jurisdictions, and personnel involved in decision making and management activities. This workshop was designed to provide a structured forum to address some of the key scientific and organizational challenges facing the San Diego MSCP. It is hoped that addressing these challenges in the MSCP provide valuable insights to a much broader range of habitat conservation programs.

MONITORING ECOLOGICAL SYSTEMS

Monitoring to detect ecological change is an important component of many environmental and conservation programs. Developing effective monitoring programs for conservation plans is scientifically and logistically challenging and many monitoring programs have been criticized as naïve, inefficient, and in many cases, inadequate (NRC 1995, Legg and Nagy 2006, Lindenmayer and Likens 2009). Common problems plaguing multispecies conservation programs include the lack of clearly defined and measurable goals and objectives, inadequate statistical design or power, poorly standardized data collection, ineffective data synthesis and analysis, and poorly coordinated management activities (Peterman 1990, Fuller 1999, Atkinson et al. 2004, Legg and Nagy 2006, Knight et al. 2008, Lindenmayer and Likens 2010). Overall, there is a lack of feedback between ongoing monitoring/management activities and the broader evaluation of progress toward meeting the program's goals and objectives (Atkinson et al. 2004, Kiesecker et al. 2007, Lindenmayer and Likens 2010, Franklin et al. 2011). Several studies have reviewed and critiqued monitoring programs in North America (Marsh and Trenham 2008) and Europe (Lengyel et al. 2008) which provide a broad framework for evaluating such programs.

The science of ecological monitoring and management is improving partly in direct response to the criticism of earlier efforts (CDFG 2003, Bormann et al. 2007, Koontz and Bodine 2008). In addition, there is greater awareness of the organizational, institutional, and logistic challenges (Imperial 1999, CDFG 2003, Atkinson et al. 2004, Hierl et al. 2005, Manring 2007). In 2004, Atkinson et al. published a comprehensive user's guide to the development of monitoring programs to support adaptive management in multi-species plans. A main recommendation of the Atkinson et al. report (echoed by nearly all of the other papers on multi-species management – Lindenmayer and Likens 2010, Flieshman et al. 2011, Franklin et al. 2011) is that the process is iterative and requires re-evaluation of all the steps.

The goal of this workshop was to review the existing monitoring and management efforts within the MSCP South in order to collectively identify the challenges and prioritize next steps. The structure of the workshop was designed to identify areas of consensus, identify and explore areas of disagreement, and to prioritize next steps that will ultimately lead to efficient and effective regional management and monitoring efforts.

Dahlem Conference Model

The following chapters are the result of a three-part structured workshop which was organized around the Dahlem Konferenzen model originally hosted at the Free University of Berlin starting in the mid 1970's. (Freie Universität Berlin 2007). Dahlem Workshops are a structured way to foster scientific creativity, the exchange of information and ideas, and the development of new theses. As part of this process, Dahlem workshops are designed to identify areas of broad consensus as well as expose and elaborate areas of contention and disagreement. Through this process, the Dahlem conference is intended to help set an agenda for future work that will improve the state of the art.

In Dahlem conferences, experts with different backgrounds and/or views are invited to participate. Participation is by invitation so that the size of each working group is not so large as to be impractical. Participants assess the current state of the field by reading background papers prepared for the workshop. The themes of the workshop are discussed in order to identify gaps in understanding, finding possibilities for convergence in disputed issues, and influencing the direction of future activities. Through these intensive preparations, the workshop can begin where regular conferences usually end: with discussions, the debate of questions, and collective thinking.

At the beginning of the workshop, each working group decides on its own program. During the workshop each group prepares a group report documenting its discussion. At the end of the workshop, the results are brought together in the plenary sessions, presented, and discussed by all participants. Ultimately, the findings of the workshop participants are collected in a book or report.

Adaptation of the Dahlem Model to the MSCP

We adapted the Dahlem model to work in a setting that is less academic (participants included academics, scientists from governments, resource agencies, and NGOs, as well as land managers and conservationists). At the same time, participants were more constrained both in terms of time they could commit to a workshop as well as time they could invest in reading and writing outside of the actual workshop. As a result, the conference organizers took a more central role in organization of the workshop, development of the initial materials, as well as editing the final papers.

The workshop was hosted in three parts (Figure 1). The first part was a half-day introduction to the workshop. During this first workshop, we presented an overview of the workshop structure and expectations for participants. We then introduced the three topics and presented background materials for the participants (including a resource CD with references and other materials). Participants were assigned to the three groups in an attempt to balance groups in terms of participant's expertise as well as their affiliations. Groups then met and elected their facilitator, rapporteur (secretary or recorded). They also selected a third person to be the group "nagger" or "reminder-er" who volunteered to help assure timely responses from the participants, all of whom are volunteering their time above and beyond their regular responsibilities.

The second part of the workshop was a full day centered on group discussion. This was scheduled two weeks after the initial meeting to give participants time to read and prepare. This second portion was the most active and unstructured. Groups were given the task of completing an outline of their paper by the end of the day. They were also expected to complete timeline for writing and editing of this paper.

The third part of the workshop was another half-day meeting designed for discussing the initial reports from each group. This was important since the Dahlem model is structured to encourage inter-group communication and discussions. Each group presented a short presentation of their paper and these were opened for discussion and input.

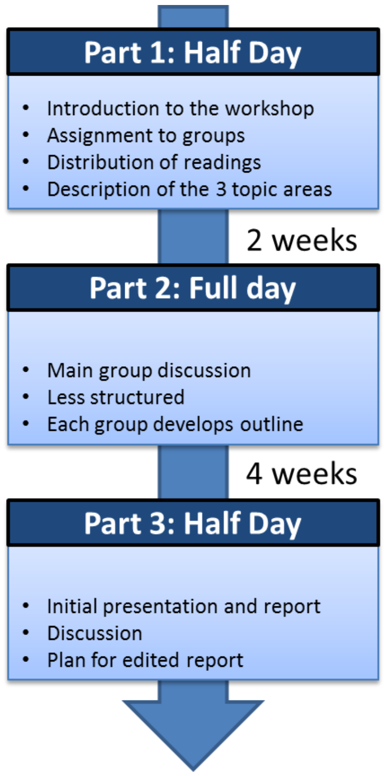

Figure 1: Structure of the workshop in the Fall of 2010.

THREE TOPICS FOR THE MODIFIED DAHLEM CONFERENCE.

The three topics for this workshop were chosen and refined by a small ad-hoc steering committee. The steering committee identified three grand challenges in the successful monitoring and management of multi-species, multi-jurisdiction conservation plans (Table 1). The first group focused on the challenge of monitoring and management at scales ranging from meters to thousands of kilometers. This is further complicated by the life-history of species that range from small populations of endemic plant species to wide-ranging mammals and birds. The second group focused on developing strategies to integrate efforts across many species and the broader function of the ecosystem. HCP and NCCP plans are designed to protect the ecosystem that supports species and yet defining ecosystem function remains difficult. We cannot possibly monitor and manage for something we cannot define and measure. The third group focused on the human – natural system interface. This group grappled with the social, political and economic forces that impact monitoring and management on the ground. Although these three themes are not independent of each other, the groups tried to maintain focus on their own topical area.

Table 1: Three major topics of the Dahlem Conference.

Topic	*Description*
Preserve to Region *(Spatial Scale in Management and Monitoring)*	Monitoring and management must occur at several scales from individual preserves or isolated populations to reserve networks and species that can move thousands of kilometers. Prioritization and coordination across these scales is scientifically difficult because it depends on the interaction between the spatial structure of the environment and the life history of species.
Species and Ecosystems *(Organizational Level in Management and Monitoring)*	The two main goals of the MSCP are to protect a long list of individual species as well as the integrity and function of the ecosystem in which they are embedded. It is impractical and inefficient to allocated equal resources to all covered species. Instead, it is important to prioritize and coordination monitoring and management among species. Moreover, evaluating a plan's adequacy in protecting ecosystem integrity requires careful specification of the nature of integrity or function. Finally, monitoring and management effort has to be optimized among species and ecosystem properties. Developing a coherent rationale for allocation of effort is scientifically complex and as a result it is often controversial.
Impediments and Solutions *(Inter-Organizational Structures)*	Monitoring and management exist at the intersection between natural and human systems. The social, political, economic, and even inter-personal dynamics can make or break a conservation program. Identifying the common impediments to effective monitoring and management is necessary to develop strategies that improve future efforts. It is important that this effort is transparent and open to critical re-interpretation.

GROUP 1: REGIONAL AND LOCAL MONITORING AND MANAGEMENT

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How do we ensure that the San Diego Regional Preserve System is effectively managed across jurisdictional boundaries and ecological scales? Is it possible to monitor at the reserve level and integrate these efforts so they are meaningful for the individual preserves and the larger ecoregion? This paper addresses different approaches to monitoring, how monitoring protocols can address ecological variability at different spatial scales, and how the results of this monitoring can answer questions across time. It is essential to focus on collecting biologically meaningful data that can be utilized to inform management actions at various scales. It is equally important to avoid collecting data for the sake of data collection. As a result, the primary focus of monitoring efforts must be to inform management actions and secondarily to meet regulatory requirements. In some cases, both goals may be achieved with the same data. This prioritization will help ensure that available resources are allocated for actions that benefit the covered species and the ecosystems on which they depend, while simultaneously meeting regulatory requirements.

BACKGROUND

The South Coast Ecoregion falls within the California Floristic Province, a global biodiversity hot spot (Myers et al. 2000). Rapid urban development in the region has led to the loss and fragmentation of natural habitats, resulting in an unusually high number of rare, threatened and endangered plant and animal species in southern California (Dobson 1997). In the early 1990s it was recognized that biological resources were not being addressed at the proper scales. Project-by-project review and regulatory permitting produced highly fragmented landscapes with no long-term plan for maintaining the incredible biodiversity. Local jurisdictions, environmental organizations, and the resource agencies began working together to develop a different way of planning to conserve sensitive species, their natural habitats and overall biodiversity. It was acknowledged that planning needed to be implemented in a proactive and regionally coordinated fashion similar to other infrastructure such as roads and wastewater systems.

The coastal California gnatcatcher (*Polioptila californica californica*) was listed as federally-threatened by the USFWS in 1993 (USFWS 1993), which provided a regulatory catalyst to start planning for open space at a regional scale. Concurrent with the listing of the gnatcatcher by the USFWS, the State produced Conservation Guidelines and other documentation to support the Southern California Coastal Sage Scrub Natural Communities Conservation Program (NCCP) (CDFG 1993). This served as the pilot program for the first NCCP, and the gnatcatcher was selected as the flagship species for this program and the South Coast Ecoregion. The other two target species identified at that time were the coastal cactus wren (*Campylorhynchus brunneicapillus sandiegensis*) and the orange-throated whiptail (*Aspidoscelis hyperythrus beldingi*). Although coastal sage scrub extends beyond the ecoregion, the planning area was initially limited to Orange, Riverside, San Diego counties and the Pales Verdes Peninsula in southern Los Angeles County (Figure 2). This area is isolated from the coastal sage scrub habitat in the more north-westerly areas of Los Angeles and Ventura Counties by urban areas and therefore did not extend further north; the initial focal area captured the overlapping distributions of the gnatcatcher, cactus wren and whiptail. These species were used to help focus the initial planning efforts, but only cactus wren and gnatcatcher continue to be focal species for management and monitoring during the implementation phase for the San Diego NCCPs.

Figure 2: **The South Coast Ecoregion.** Base map drawn from CA DFG Bios and ACE-II web tools. Red lines indicate the CA DFG ecoregions designated in their GIS tools. The shaded area denotes the subset we refer to as the South Coast ecoregion. It is comprised of portions of the Southern California Coastal and Southern California Mountains and Valleys (Cleland et al. 2007).

There was general consensus among the stakeholders that planning should be done on a "regional" scale. A Scientific Review Panel was convened to draft conservation guidelines for the southern California coastal sage scrub NCCP area. The planning area was divided into subregional planning areas based on political jurisdictions, landscape features, and biological parameters for planning purposes. The NCCP plan in Orange County focused primarily on coastal sage scrub habitat and associated species while the plans in Riverside and San Diego Counties included all habitats within each planning boundary. In San Diego County the decision was made to develop plans at the multi-jurisdictional level but to implement them at the jurisdiction level utilizing each entity's land use authority (Figure 3). This has resulted in preserve management responsibilities being dispersed amongst various entities and jurisdictions with a collective responsibility to achieve the regional preserve system biological goals.

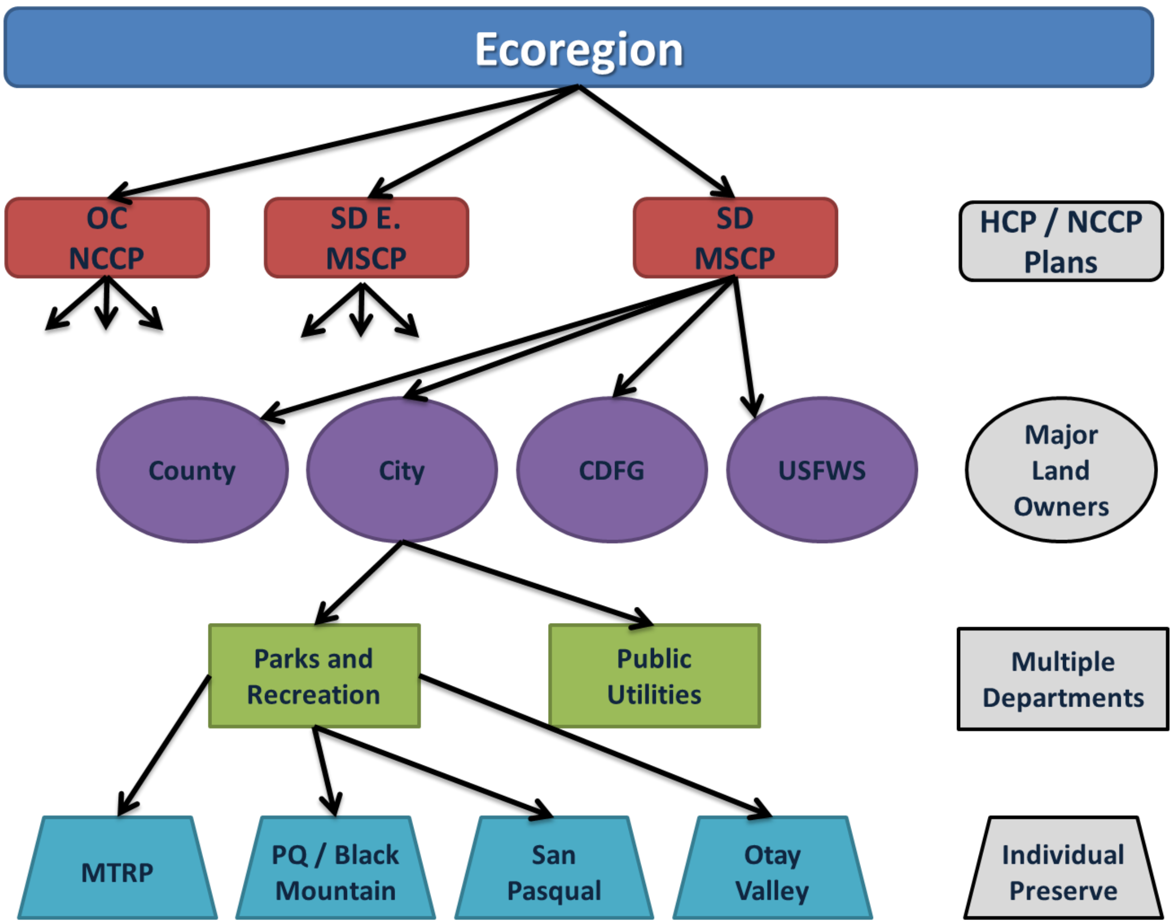

Figure 3: Different organizational and spatial levels involved in monitoring, adapted from figure 2 in Atkinson et al (2004). At In red at the top level are three HCP/NCCP Plans (OC- central Orange County, SD E.- San Diego East, MSCP – San Diego South). The purple ovals represent major land owners within the MSCP (County of San Diego, City of San Diego, CA Department of Fish and Game, and US Fish and Wildlife Service). The green rectangles show that land is managed by two different departments within the city of San Diego. Finally, the bottom row shows that there are multiple lands managed by the Department of parks and recreation (MTRP – Mission Trails regional Park, PQ – Penasquitos).

Since significant portions of the preserve system have been assembled, there is now a focus on how to adaptively manage and monitor the preserves as a system rather than as individual preserves. While maps can be used to show the juxtaposition of conserved land parcels and associated habitats, effective and appropriate management and monitoring will require those responsible for management and monitoring to utilize a more holistic approach (Table 2).

Table 2: Key challenges to developing more effective monitoring and management

Issues/challenges that have to be addressed include:

- Species management and monitoring
- Habitat management and monitoring
- Management and monitoring across jurisdictional boundaries,
- Coordinated data analysis and interpretation,
- Effective and efficient utilization of available funding
- Clear identification of tasks and
- Acceptance of associated responsibilities by specific entities

Questions that arise from these issues include:

- How are threats and stressors that affect habitats and species at multiple scales going to be addressed by funding decision makers and land managers that may not have the authority for actions at the appropriate scale?
- What should an individual preserve manager monitor to help inform their management at the preserve-system scale?

PRINCIPLES OF MONITORING FOR BIOLOGICAL CONSERVATION

Monitoring should be purpose driven. Monitoring in a multi-species conservation framework generally satisfies one of two needs: (1) implementation (also known as mandated or compliance monitoring) and (2) effectiveness monitoring (Atkinson et. al, 2004). Implementation monitoring focuses on the reserve structure itself. For example, implementation monitoring would evaluate whether a permittee conserved the right amount of lands or applied the correct mitigation ratio. Effectiveness monitoring is a necessary next step. It measures the status and trend of resources, the status and trend of pressures (threats/stressors) and the effects of management actions. It may also include targeted studies that are hypothesis driven and also is intended to provide information on mechanisms (population dynamics, ecological processes) underlying the measured trends (Lindenmayer and Likens 2010; Atkinson et al, 2004).

Effectiveness monitoring is generally question-driven and is based upon a conceptual model with a well thought out study design that provides information on drivers of ecological processes (Atkinson et al 2004, Lindenmayer and Likens 2010). It is especially useful to land managers, researchers and decision makers as it has predictive capacity, allowing the comparison of management actions and an understanding of cause and effect relationships. Question-driven monitoring is often experimental in nature and provides data that reduces uncertainty in knowledge about population dynamics, ecological systems or management techniques.

Implementation monitoring is not intended and cannot detect long-term trends in species status or community processes. This form of monitoring is often a result of legal requirements. The detailed form of monitoring is often negotiated between the wildlife agencies and the permittees. These negotiations are often conducted before the preserve is assembled, and without enough information to predict the spatial and temporal processes which will necessitate monitoring and management activities. As a result, it is often difficult to integrate a question-based monitoring framework and sampling strategies that both satisfy plan-mandated monitoring requirements and collect information about factors affecting the monitoring target. Therefore the first step in developing a long-term monitoring program is to develop clear, measurable conservation goals and objectives for each species and habitat covered under the plan (Atkinson et al. 2004, Hierl et al. 2007).

Effectiveness monitoring should be based on a conceptual model that depicts threats and natural processes predicted to affect a species or a natural community. These relationships should guide development of a sampling program that incorporates information on these threats and drivers. Together, these data can be used to evaluate the strength of association between metrics measured for the monitoring target and the identified threats or other processes. (Hierl et al 2005, Atkinson et al 2004 and Fancy et al. 2009)

Monitoring is a time-dependent process and can vary widely depending on project goals and sampling design. It can include both qualitative and quantitative elements, utilize sampling methods or complete counts, utilize various types of telemetry or mapping (spatially explicit and comprehensive description or quantification of landscape phenomena or properties), conducted over time. Similarly, the response to management actions may vary widely among preserves and in different years. As a result, the long-term program will likely be iterative, involving multiple experimental trials to distinguish the effectiveness of alternative management actions. Stakeholders and land managers should work together to identify when adaptive management or targeted studies should be employed to better understand causal relationships underlying trends or to determine the efficacy of alternative management actions. The group should also participate in developing the appropriate questions and defensible study designs for adaptive management actions or targeted studies.

Spatial and Temporal Scale Relationships

Spatial and temporal scales of ecological processes, as well as measurements of such processes can be characterized by grain (fineness of detail) and extent/duration (domain of coverage). The characteristic spatial and temporal grain and extent/duration requirements will vary for both regulatory and adaptive management purposes of monitoring.

Ecological patterns vary depending upon the scale, as do the underlying mechanisms that drive these patterns (Levin 1992). There is no single appropriate scale for understanding all ecological processes and change (Levin 1992). This complicates monitoring, as it is difficult to determine the temporal and spatial scale to which a monitoring program should focus (du Toit 2010). In designing long-term monitoring programs it is important to consider the target of monitoring and the appropriate scale. It may be that several different scales are considered or tested before a monitoring plan is finalized (du Toit 2010). For instance, a monitoring program devised for an endemic plant species occurring at a few well-defined locations will differ considerably from a monitoring program for a widespread species or plant community that is distributed over a large area with highly variable environmental conditions (see Figure 3). Typically, question-driven monitoring, often in the form of experimental studies, occurs at a small-scale, making it difficult to generalize results (Lindenmayer and Likens 2010).

SPATIAL SCALE

Regional effectiveness monitoring is primarily oriented toward understanding status and trend of covered species at the reserve system and regional levels. The statistical design of a regional monitoring program should have adequate coverage at appropriate spatial scales, be consistent through time, and minimize effort or cost. The design should be based on knowledge of habitat relationships. The spatial scale of sampling will depend largely on the species overall distribution, the scale of the territory or home range, and whether the species is clustered or more evenly distributed throughout the reserve system.

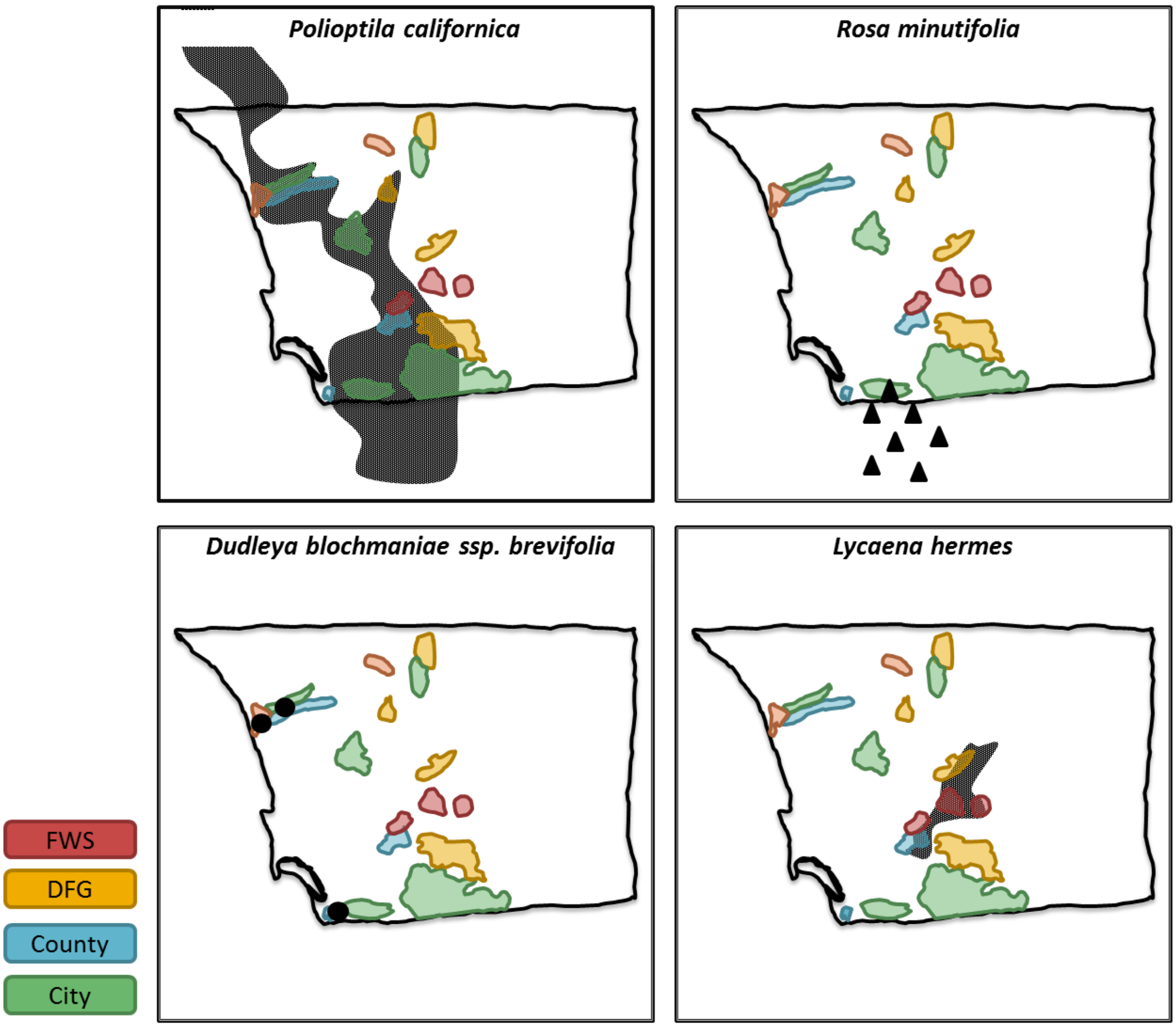

Figure 4: Examples of spatial scales relative to reserve configuration and the distribution of species of interest. This figure is loosely drawn from examples in San Diego, although some artistic license has been taken. The shaded regions indicate lands owned or managed by different entities including US Fish and Wildlife (FWS), CA Department of Fish and Game (DFG), and the County or City of San Diego. The black symbols or shading indicate known populations of the covered species. The four species were chosen to illustrate different issues including a single discrete populations (Rosa), several discrete populations (Dudleya), a very restricted range (Lycaena) and a broader range that extends outside of the plan area (Polioptila).

An important consideration when designing a spatial sampling strategy is the vegetation communities that the species tends to occur in and the extent to which these communities are distributed across the landscape. Developing a strategy to monitor abundance and trends for many individual species will be a trade-off in collecting detailed information that describes long-term trends in distribution patterns and abundance in a single species versus collecting some data on many species. The monitoring strategy adopted must inform regional status as well as be relevant for management at the preserve-scale. For widespread species, spread out across the reserve system, it will be important to sample at each preserve with the potential to support the species. The number of surveys at each preserve will depend on the amount of potentially suitable habitat. Care should be taken to design a sampling strategy that samples suitable habitat across the landscape either randomly or in a stratified manner, based on habitat characteristics.

Spatially-explicit habitat suitability models or niche models provide powerful tools for monitoring conserved species (Scott et al. 2002, Elith et al. 2006, Rotenberry et al. 2006). Habitat suitability models are created using abundance, density, or presence-absence data for the species of interest (Guisan and Zimmerman 2000, Elith et al. 2006, Preston and Rotenberry 2006). Improved Geographical Information Systems (GIS) software and digital environmental layers and new modeling techniques allow the creation of multivariate species' habitat models over a large geographic area. These regional models incorporate hypotheses about a species' occurrence relative to environmental conditions across the landscape of interest. Habitat suitability models are particularly useful in identifying areas to survey for rare species when the spatial distribution of that species is not well described or known (Preston and Rotenberry 2007, Syphard et al. 2009). Using habitat models to identify potential sampling locations facilitates a more efficient use of survey resources by targeting sampling to those areas where the species is most likely to occur. Once additional species location data are collected, they may be used to refine the models as needed and increase predictive power in targeting surveys to new areas where the species is likely to occur.

Monitoring programs must also track threats and stressors that drive population and ecosystem changes. These drivers also occur at a variety of scales that must be addressed by monitoring and management (Figure 5). Habitat models can also be used to predict changes in species distribution and abundance in reserve systems as a result of changing environmental conditions, such as climate change (Hannah et al. 2005, Preston et al. 2008, Franklin 2010, Lawson et al. 2010). Modeling approaches are being developed that incorporate other threats to species, such as urbanization and altered fire regimes (Syphard and Franklin 2009, Lawson et al. 2010). These threats can be incorporated into future climate scenarios to predict where species might occur in the future under global change. Output from these models can be used to design spatial sampling strategies that detect whether species are undertaking distributional shifts in response to environmental change.

Temporal Scale

Monitoring plans should be developed for each species or group of species to enable tracking of population trends and distribution patterns over a long time frame. The key is to sample populations in a spatial manner that ensures consistent and comparable estimates over time (Deutschman et al. 2005). This is more likely to be achieved when the same, well-trained crews are conducting the monitoring. The temporal frequency of sampling will depend on the population dynamics of the target species as well as time scales of associated stressors. Annual variation in climate, in particular the timing and amount of annual precipitation, can affect populations through influences on productivity and survivorship. It may be necessary to sample each species annually for a period of five or more years to determine normal fluctuations in population abundance. Once this baseline of population dynamics is determined, a sampling scheme can be developed to detect long-term population trends or abrupt changes in population that may warrant targeted studies and management actions.

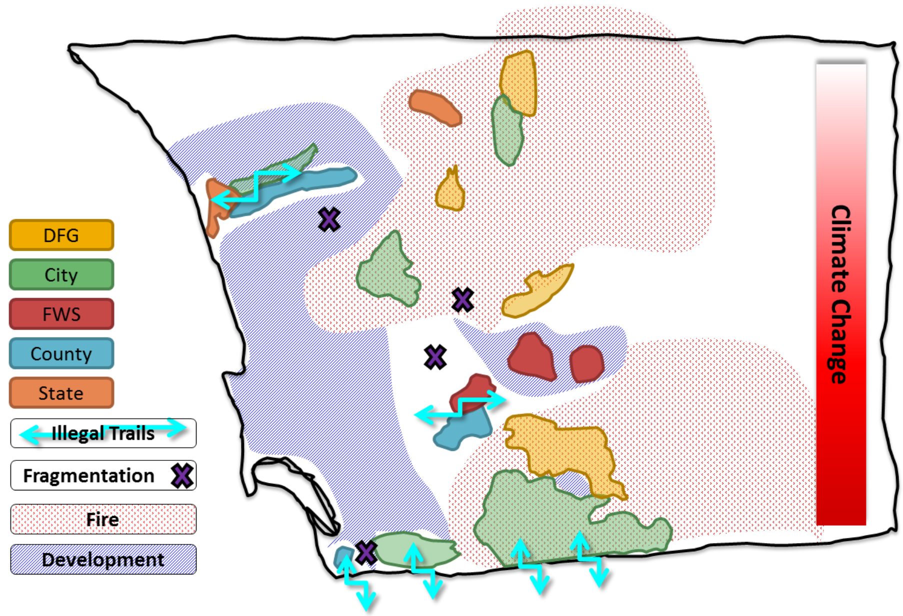

Figure 5: Stressors that drive population and ecosystem change occur at multiple scales. This figure superimposes threats and stressors over a map showing land ownership and management. Illegal trails are a problem throughout the region, but there management is inherently local. In contrast, fire management must be coordinated at broad scales. In addition, some stressors like climate change operate on longer time scales.

Species versus Community Sampling and Collection of Environmental Data

Multi-species plans require that monitoring and management protect a long list of individual species as well as the ecosystems in which they live. It may be possible to monitor groups of species simultaneously in order to more efficiently use limited monitoring resources. For example, to sample reptiles and amphibians pit fall trapping allows the collection of data on a diverse suite of species. Riparian birds are another example of where point count surveys of the entire bird community are effective at collecting information on several species of conservation concern as well as potential threat species (e.g., Brown-headed Cowbird and European Starling). Whenever sampling a single species or a community, it is important to collect information on habitat characteristics including threats to species. These data can be categorized at each survey location during sampling and some types of data can also extracted from GIS digital layers. Data collected on habitat characteristics and levels of threat can be included as predictors in models that identify species' habitat relationships in relation to occupancy patterns (e.g., Winchell and Doherty 2008).

Species Monitoring

Large-scale, preserve-wide species and community sampling surveys should be designed or coordinated by a regional monitoring entity or group, as this allows sampling across the reserve system in a consistent manner. In many cases there may be regulatory permits and specialized training requirements in order to survey for a particular species. Preserve managers may need to conduct their own surveys to gather information on impacts to sensitive species populations from infrastructure projects or recreation activities. These surveys would be independent of these long-term trend surveys, which are unlikely to sample each preserve at the spatial resolution necessary to evaluate impacts. It is important to have protocols that reserve managers can use that ensure data collected are compatible with data collected by the regional monitoring entity.

Habitat Monitoring

Monitoring for adaptive management purposes should be oriented towards monitoring habitat conditions and characterization of ecosystem variability associated with stressors. While managers may be interested in spatial and temporal variability of covered species populations within their reserve, the spatial scale of their preserve may preclude obtaining such data with any statistical reliability. Because of this spatial issue, adaptive management actions may have to be primarily focused on habitat condition at the individual-preserve level and its response to stressors. Knowledge of habitat dynamics enables managers to take actions such as removing invasive species, restricting access by humans, domestic animals, and recreational vehicles, habitat restoration, or attempting to control biophysical properties (e.g., water and nutrients) that limit or enhance ecosystem functioning. While most management currently occurs at the individual preserve level new programs are encouraging land managers to implement management at the preserve system level, so the spatial extent of habitat monitoring may need to occur at multiple scales. As with species monitoring, field protocols and data sets should be consistent and comparable across reserve system and regional scales to enable assessment of habitat health over large areal extents.

Three general approaches to habitat monitoring include:

(1) Field-based field surveys of floristic species composition and/or soil properties and monitoring of stressor either directly or indirectly.

(2) Remote sensing based mapping of vegetation life-form cover fractions and/or vegetation structure

(3) Habitat and/or vegetation community mapping

(4) Integration of one or more of these approaches

Table 3: Three approaches to monitoring habitat condition (adapted from Hamada et al, accepted)

Method	1) Field-based Surveys	2) Remote Sensing of Life-form components	3) Community Type Mapping
Biological Scale	Species composition	Life-form type generally coarse	Community type
Spatial Grain	Fine (e.g. 10 m)	Moderate	Coarse (e.g. >30 m)
Spatial Extent	Sampling plots	Wall-to-wall	Wall-to-wall
Cost	Moderately expensive	Inexpensive	Expensive
Temporal Frequency	Depends on inter-annual variation	1 to 3 years	Decadal

Field Surveys and Stressor Monitoring

One approach to monitoring habitat condition is to sample plant and/or animal species composition and/or soil properties within plots, along transects, or through some combination of plots, transects or other methodologies. The advantage of this approach is that very detailed estimates of plant species cover, exotic and invasive species density and/or stature/structure, as well as soil or water properties such as bulk density, moisture and organic content, ph, dissolved oxygen etc can be obtained. This approach is suitable for obtaining species community data at both a coarse and fine scale. The disadvantage is that such measurements require a great deal of person power and significant effort may be needed to develop a sampling design so the data can be used to characterize the reserve or reserve system. This can be due to site-specific influences associated with land use history, stressor variability, and ecosystem properties (e.g., associated with topographic position). While it may be difficult to extrapolate temporal trends of species occupancy and/or cover to other locations, the aggregation of plot level estimates at the reserve system and regional scales is likely to capture variations due to regional preserve system and regional-scale stressors such as fire, drought, climate change, and air pollution. One approach for increasing representativeness is the use of panel analysis (Urquhart and Kincaid 1999).

Remote Sensing

Remote sensing approaches to monitoring habitat condition enable spatially-explicit and comprehensive estimation of more general compositional or structural properties of vegetation and land cover (Coulter and Stow 2009; Stow et al. 2008). The two properties of vegetation of likely interest for multiple-species conservation in the NCCP planning region that are most amenable to remote sensing are life-form cover (e.g., shrub, sub-shrub, herbaceous and bare) derived from multispectral image data (Hamada et al., accepted) and vegetation structure (i.e. height and density) derived from scanning LIDAR data (Riaño et al. 2007). The advantage of this monitoring approach is the complete (“wall-to-wall”) sampling characteristics and the relatively low cost of data collection over large areas, enabling regular (interannual) and comprehensive monitoring of habitat conditions. Life-form cover or bare fraction can be estimated to within an accuracy of about 10% (Hamada et al. submitted; Witzum and Stow 2004) The primary disadvantage is that only a few species can be identified definitively, the cover estimates have lower accuracy and greater uncertainty than field-based estimates, and because of its coarse filter, may not provide data that informs year-to-year management decisions.

Mapping

A third monitoring approach is to map and digitally encode vegetation community type units and periodically update GIS layers depicting community type maps, to determine changes associated with type conversion, fire and air pollution. Changes in land use and habitat loss would also be detected and could be compared with the data available from the conserved lands database. Mapping and updating are based on high spatial resolution remotely sensed ortho-imagery, primarily used in conjunction with field plot sampling and field reconnaissance. An example is the approach being implemented by SANDAG and Cal Fish & Game that is based on the Keeler-Wolf classification system and mapping protocols (Evans and San 2005). Updates are likely to be made on a decadal basis and conducted through image change analysis followed by detailed field reconnaissance. The actual update frequency depends on the spatial and temporal frequencies of stressors (e.g. wildfire frequency and land use changes) that can alter community types. The disadvantage of this approach is that habitat conditions may change within mapped vegetation community units and not be detected or quantified.

Habitat Connectivity Monitoring

As habitat becomes fragmented, populations occupying larger, contiguous patches of habitat become more isolated in the remaining habitat patches. Smaller populations are at greater risk of extirpation due to stochastic and anthropogenic events (e.g. chance demographic and genetic events, catastrophes, and environmental variability, introduction of exotic species and disease, etc.) (Shaffer 1981). Connectivity between habitat patches can help reduce the risks to species and populations from stochastic and anthropogenic effects through:

- Access to resources via within-home-range movements, migration, etc.
- Demographic exchange (dispersal, recolonization, demographic rescue, etc.)
- Gene flow (including potential for adaptation and evolution)
- Maintenance of ecological function including food web dynamics and other trophic interactions, and species movement among core areas and habitat patches
- Providing opportunities for shifts in species geographic ranges in response to environmental change such as climate change.

Maintaining connectivity amongst core areas and to lands outside of the plan areas is essential for maintaining the biodiversity of the preserve system and resilience of species and natural communities in the San Diego region.

Knowing if an individual of a species has traversed a chokepoint is helpful for addressing potential connectivity but only allows for inferences regarding the functionality of the linkage as a whole. Recent research utilizing genetics has demonstrated that merely documenting animal movement past a chokepoint does not necessarily result in functional connectivity (Riley et. al 2006). To meet the connectivity goals of the plans, understanding if and how core areas are functionally connected is critical. This information will determine if a plan needs to manage for groups of a species that are part of a larger population or groups that are isolated despite the existence of nearby populations. The current level of connectivity is important for informing management decisions for a wide variety of species, including those species that move on the ground, along or within water columns, through the air or by hitchhiking on other species. While most connectivity is achieved by an organism moving from one area to another, in plants, functional connectivity may also be the result of pollen moving between populations.

Connectivity monitoring utilizes various approaches including banding, tracking, camera traps, genetic analysis, stable isotope analysis, tracking disease, or telemetry. The question and species being addressed generally determine the monitoring methods utilized for connectivity monitoring studies. Determining functional connectivity generally requires some measure of reproductive success, breeding, and/or gene flow.

Threats and Stressors

The terms threats and stressors have often been used interchangeably in the literature. Others have suggested that the distinction between the two terms is illustrated by describing threats as the overarching term and stressor as the more specific causative term (See Table 4). This hierarchical classification is useful for many threats but not all. We use the term threats/stressor to be inclusive rather than implying any hierarchical classification of the two. Threats/stressors are also identified as risk factors in the literature. There are multiple definitions of these terms in the literature including the following:

- "an action that imposes changes on an ecological system," *US Naval Guidelines, Ecological Risk Assessments, 2006 at http://web.ead.anl.gov/ecorisk/index.cfm)*
- "factors that disrupt equilibrium and include both natural processes and the human activities that exert stress on natural communities," *(Chicago Region Biodiversity Council, 1999).*
- "the activities or processes that threaten the viability of populations and cause negative trends in population size," *(Regan et al 2006)*

Table 4: Examples of general Threats and specific stressors

Threat	Stressors	Threat	Stressors
Urban Development	Fragmentation Lighting Urban runoff Argentine ant invasion	Recreation	Fragmentation Direct mortality Disturbance of animal behavior Erosion and sediment
Roads	Fragmentation Direct mortality Noise Altered hydrology at bridges	Wildfire	Food availability Shelter Increased access to habitat by threats Erosion and sediment
Climate	Water Food availability Increased potential for wildfires Increase pests		

DEFINING SCALE OF THREATS/STRESSORS

In San Diego County, natural populations are faced with a myriad of threats that operate at different levels of intensity and spatial and temporal scales (Figure 5 above). Hierl et al. (2005) recommended that any monitoring plan designed for the purpose of informing future management activities explicitly consider the spatial and temporal scale of these threats and stressors. Regan et al (2006) identified a list of stressors that were utilized as part of their risk assessment for the 85 MSCP Covered Species. They identified three species monitoring risk groups, with Risk Group 1 being the highest priority for species population monitoring.

While monitoring populations may provide important information regarding status and trend, it does not provide a full picture of why a population may be changing and therefore what the management focus should be (e.g. controlling predation, controlling invasive species, fuels modification to reduce the severity of fire, etc.). Collecting data on key drivers derived from a conceptual model can help us better understand what environmental factors may be changing over time, but the data collected must be at the appropriate scale relevant to the threat/stressors as well as the response of the species and/or natural communities. Information on threats and stressors can be classified by intensity/severity, spatial extent, and time period. These processes and scales need to be integrated in assessing threats and stressors (Table 5).

Table 5: Matrix showing the Severity and scales of threats/stressors for a sample set of species.

Threats and Stressors	Recreation			Exotic Species	Wildfire		Roads	
	Hiking	Dogs with hikers	Trail Riding		Frequency	Intensity	Direct mortality	Habitat fragmentation
Immediacy (Temporal Scale)								
Golden Eagle	Moderate	Long Term	Immediate			Long Term		
California Gnatcatcher				Moderate	Long Term	Moderate		
San Diego Thornmint				Long Term	Immediate			
Mountain Lion					Immediate	Long Term	Long Term	Long Term
Pond Turtle		Moderate		Long Term		Long Term	Long Term	Long Term

Legend: Immediate <5 years: Moderate, 5-10 years: Long Term, 10+ years

Extent (Spatial Scale)	Hiking	Dogs with hikers	Trail Riding	Exotic Species	Frequency	Intensity	Direct mortality	Habitat fragmentation
Golden Eagle	P	P	P			P		
California Gnatcatcher				PS	PS	PS		
San Diego Thornmint				P	P			
Mountain Lion					P	P	PS	PS
Pond Turtle		P		PS		PS	R	R

Legend: P, Preserve: PS, Preserve System: R, Region

Urgency (Severity)	Hiking	Dogs with hikers	Trail Riding	Exotic Species	Frequency	Intensity	Direct mortality	Habitat fragmentation
Golden Eagle	**	**	**			***		
California Gnatcatcher				*	***	***		
San Diego Thornmint				***	*			
Mountain Lion					*	*	***	***
Pond Turtle		**		***		**	**	***

Legend: *, somewhat important: **, moderately important: ***, very important

Allocating Effort across Spatial Strata

Hypothesis based and conceptual model driven effectiveness monitoring is difficult. It requires multiple human structures (cities, counties, NGOs, and others) to develop monitoring programs that fit with the temporal and spatial scales at which ecological systems need to be monitored and adaptively managed.

The appropriate entity to conduct monitoring activities will depend on a number of considerations. Some of these include the identity of the species, community or ecosystem that is being monitored; the type of attributes to be measured; the spatial extent across which monitoring will be conducted; the temporal frequency and duration of monitoring activities; the requirement for specialized expertise or regulatory permits; and the resources available to entities to carry out the monitoring. At the local scale, reserve managers may be very effective at monitoring specific, small-scale threats or isolated populations restricted to a very limited area, whereas regional monitoring teams are most likely to be more effective in cases where the species, community, ecosystem or threat is widespread across the region, requires complicated sampling or extensive training, expertise, or regulatory permits, or is a targeted and time-consuming study.

ECOLOGICAL STRUCTURES: HARNESSING WHAT WE KNOW ABOUT VARIABILITY

Monitoring and management must capture spatial and temporal variability in species and habitats. Southern California experiences high inter-annual climate variability, particularly in precipitation patterns. This variability has a strong effect on species, especially fecundity and mortality rates, areas occupied some species populations, and ecological processes. As such, long-term monitoring efforts may also include development of a baseline showing the natural range in responses of species, natural communities and ecosystems to this climate variability. It is important to design the monitoring program to account for natural inter-annual variability so that it can be determined when a downward trajectory is a result of a serious threat independent of the typical annual variation.

Identifying specific traits and attributes to measure can be aided by the development of conceptual models showing hypothesized relationships between anthropogenic threats and natural drivers to population dynamics of a covered species or desired attributes of a plant community or ecosystem (Atkinson et al. 2004, Hierl et al. 2007, Lindenmayer and Likens 2010). Monitoring focused conceptual models have been developed for many of the Regan et al. (2006) risk group 1 animal species and more are in preparation. Sample conceptual models for two plant communities have been developed, the coastal sage scrub plant community, and the landscape-scale upland shrub communities (Hierl et al. 2007). As adaptive management actions are considered, they should utilize the most up-to-date conceptual models. Conceptual models that have already been prepared should be further developed and integrated into the monitoring program to guide decisions on which species, plant communities and ecosystems should be targeted for monitoring. These models will also help in designing monitoring methods, identifying attributes to measure, determining how often to measure and over what time-scale, and over what spatial scale measurements should be collected.

CASE STUDIES OF SUCCESSFUL SPATIAL THINKING

CALIFORNIA GNATCATCHER – A MONITORING EXAMPLE

The City of Carlsbad's Habitat Management Plan (HMP) addresses a subarea of the subregional MHCP. The conservation analysis for the HMP estimates that 127 point locales of gnatcatchers will be preserved within the reserve (Carlsbad HMP 2004). Currently, each reserve manager allocates resources to count gnatcatchers within the preserve and document compliance with the HMP. Unfortunately these counts do not provide enough information to the land managers regarding what, if any, management actions they should be taking. These counts are difficult to interpret and don't provide adequate insight into the status of the gnatcatcher within the city and what changes (up or down) in numbers actually means. The Center for Natural Lands Management estimates that it and CDFG spent approximately $35,000 in 2009 to count gnatcatchers within the preserved lands in Carlsbad.

In a simultaneous effort, USFWS, with funding from *TransNet*, implemented a region wide study of gnatcatcher population dynamics within conserved lands in San Diego County. This was the third survey period for the MSCP (2004, 2007, 2009). The study was designed to sample habitat across the region in order to make estimates of the size of the population within the reserve as well as to look at the potential effects from the 2003 and 2007 fires. This regional sampling will likely be conducted every three years and, if designed and implemented correctly, will monitor/detect trends in the gnatcatcher population within San Diego County Preserves. In addition, many habitat covariates were also collected and analyzed; based on these covariates, habitat can be categorized as high quality, low quality, etc. If this larger study is accurately assessing/detecting the trend (up or down) of the gnatcatcher population, and providing insight into habitat quality, there is no need to count birds in Carlsbad. Instead local managers should monitor CSS habitat quality and only monitor gnatcatchers if there are specific disturbances or activities. Furthermore, these same habitat covariates may also be relevant to other coastal sage scrub species such as cactus wrens and whiptails.

Evaluating trends in habitat quality with vegetation monitoring by using consistent methodologies, as illustrated in Table 3 (above), makes financial sense because it has applicability for multiple species. In this example, Carlsbad can use the cost savings from not conducting gnatcatcher surveys in order to fund the vegetation monitoring or management. Monitoring programs should not be conducted in a vacuum. Data on population size is of little use without the collection of complimentary data on threats and natural environmental processes. Variations in these variables through time and space may correspond to variation in gnatcatcher population size, providing insights into observed population trends and suggesting management actions to increase populations or abet declines. This will avoid the pitfalls of "counting for counting's sake."

Arundo – A Management Example

Within southern California riparian corridors, the spread of invasive species has been identified as one of the major threats and stressors to the system. Many species of weeds have been identified within these systems; one species in particular, giant reed (*Arundo donax*, arundo), has been the target of extensive exotic plant removal efforts. *Arundo* is a thick-stemmed plant in the grass family, resembling bamboo, growing up to 30 feet tall. It forms many-stemmed clumps, spreading from thick, knotty roots called rhizomes that grow horizontally, not downward. The root masses can spread over several acres, quickly forming large colonies that displace other plants. This highly invasive species can spread through vegetative reproduction, either from underground rhizome extension of a colony or from plant fragments carried downstream, primarily during floods, to become rooted and form new colonies (Else 1996). *Arundo* has been the biggest problem in coastal river drainages of southern California, especially in the Santa Clara, Santa Ana, Santa Margarita, San Luis Rey, Tijuana and other major and minor watersheds, where it sometimes occupies entire river channels from bank to bank (Jackson et al. 1994). *Arundo* displaces native plant species that many wildlife species, including federally endangered species (e.g., least Bell's vireo (*Vireo bellii pusillus*)), rely on for food, shelter, and reproduction. In addition, *Arundo* is highly flammable most of the year, creating a fire hazard for other vegetation, buildings, and people. Its presence can increase both the probability of wildfire and the intensity of fires once they occur. For these reasons, land managers often focus much of their effort on the removal of this species. Unfortunately, unless their preserve is located at the top of a watershed, these well-intended efforts may not be cost effective due to continued spread from upstream areas.

Comprehensive, region-wide monitoring of *Arundo* distributions can be achieved through integration of airborne imaging and field reconnaissance. Unlike scrubland, grassland and forest habitats, riparian zones are long and narrow, enabling aircraft platforms to follow river courses and capture the entire zone in a single swath. *Arundo* has a unique visual signature on ultra-high spatial resolution aerial color imagery and a unique spectral signature on airborne color infrared imagery for a range of spatial resolutions (Hamada et al. 2005). Field reconnaissance is needed for refinement in image-derived maps and reconciliation of individual or very small patches of *Arundo*. Pertinent imagery is often readily available from extent airborne image data sets such as the USGS NAIP program. Inexpensive and flexible aircraft platforms such as small unmanned airborne vehicles (UAVs), light sport aircraft and digital cameras are promising for low-cost *Arundo* mapping in a comprehensive manner.

In drainages where *Arundo* has established itself throughout the watershed, effective control of this species must be conducted on a watershed-wide basis. Eradication efforts should generally start at the top of the watershed and work downstream. This means coordinating with multiple land owners, including private property owners, for access and resources to control the infestation. Land managers need to be educated on the value of potentially spending their limited management dollars on "up stream" property they may not own or manage.

Tecate Cypress – A Collaborative Approach

Tecate cypress (*Hesperocyparis forbesii*) is an endemic closed-cone cypress species restricted to southern California in the United States and northern Baja California in Mexico. Within southern California there are four distinctive Tecate cypress populations in Guatay, Otay and Tecate Mountains in San Diego County and the northern Santa Ana Mountains in Orange County. Small stands and individual trees are scattered along a 150 km coastal strip in Baja California, Mexico. San Diego populations are conserved under San Diego's MSCP, whereas the northern Santa Ana Mountain population is conserved under Orange County's Central and Coastal Natural Community Conservation Plan (OC NCCP/HCP). Tecate cypress populations are distributed on lands owned and managed by the Bureau of Land Management (BLM), US Forest Service, Orange County Parks, and California Department of Fish and Game. Because of the small number of widely distributed populations, this species provides an example in which local land owners/managers, regional monitoring entities and scientists can come together to develop monitoring and management actions for the entire distribution of the species.

The Nature Reserve of Orange County (NROC) is responsible for coordinating and implementing monitoring and management activities for sensitive species within the OC NCCP/HCP and completed a Tecate Cypress Management Plan in 2010 (http://www.naturereserveoc.org/). A representative of the BLM responsible for San Diego populations attended NROC's Tecate Cypress Management Committee meetings and reviewed the management plan. The BLM and the Nature Conservancy recently hosted a Tecate cypress symposium convening experts and scientists. San Diego and Orange County land owners/managers and regional monitoring/management teams were invited in order to facilitate the exchange of information important for managing populations across the species distribution. These examples illustrate there could be opportunities for these stakeholders to collaboratively apply for grant funding, identify monitoring and management needs and information gaps, develop consistent monitoring protocols, and exchange information on the effectiveness of management actions. In this example, land owners/managers are responsible for implementing monitoring and management on their lands, but do so in a manner that is coordinated and consistent at both the reserve-wide and the South Coast Ecoregion scales. If there were sufficient interest and available resources, this collaboration could be expanded to include scientists, conservation practitioners, and land managers in Baja California, Mexico.

An additional factor that increases the importance of coordinated monitoring and management of Tecate cypress is that it serves as a host plant for the Thorne's hairstreak butterfly (*Callophrys [Mitoura] thornei*, Thorne's), a geographically isolated and ecologically distinct butterfly known only to occur on Otay Mountain in San Diego County. Thorne's is a BLM Sensitive Species and a covered species under the MSCP Plan. The native plant and animal communities on Otay Mountain have suffered from dozens of wildfires. For example, the Otay Fire of 2003 and Harris Fire of 2007 have created a primarily monotypic stand of Tecate cypress.

There are critical gaps in our understanding of the ecology of Thorne's hairstreak. The status of Thorne's inside the MSCP is likely to be precarious, but is largely unknown. The amount of suitable habitat available to this butterfly is unknown, because its precise habitat requirements are unknown (Forister 2010). The restricted distribution of the butterfly renders it highly vulnerable to extirpation or extinction from catastrophic wildfire. Management and protection of the remaining few stands of Tecate cypress remains critical to Thorne's.

Various efforts on the part of SANDAG, BLM, USFWS, The Nature Conservancy, NROC and Conservation Biology Institute are underway to improve the knowledge of suitable habitat for Thorne's, as well as to understand the interactions between the butterfly and its larval host plant, Tecate cypress. Further collaboration to promote the continued viability and persistence of Thorne's and to inform the management and conservation of this species is warranted.

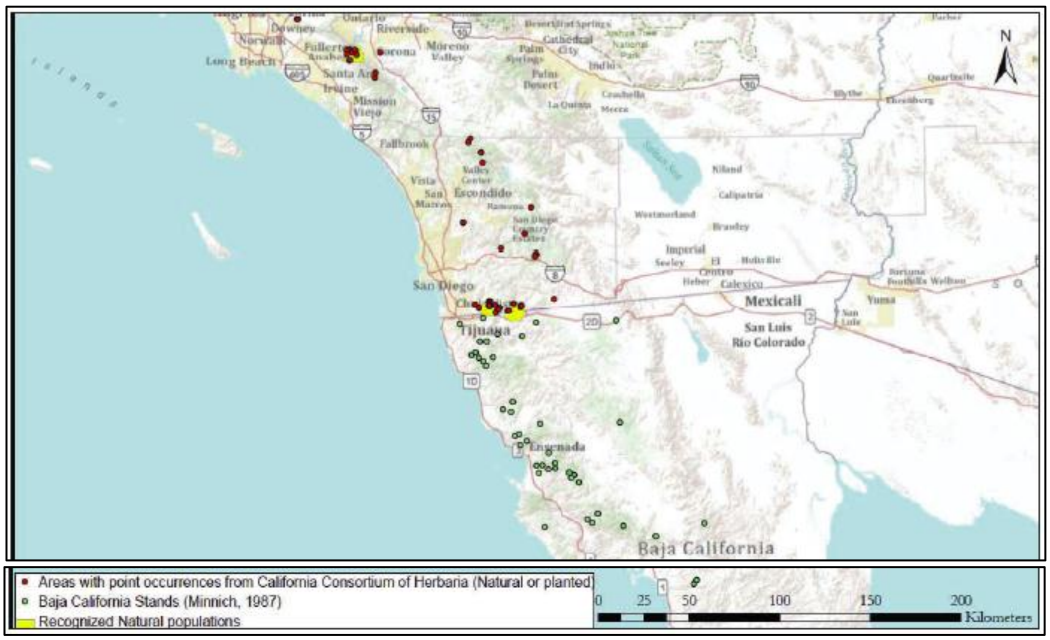

Figure 6: Distribution of Tecate cypress populations. Distributions are based on descriptions of Tecate cypress stands reported since 1948, and herbaria records (Consortium of California Herbaria 2009). Taken from Figure 2.1 in NROC's 2010 report "Santa Ana Mountains Tecate Cypress (Cupressus forbesii) Management Plan"

Summary and Recommendations

There is no single scale appropriate for monitoring and management for a complex, multiple-species conservation program like the San Diego MSCP. Scale must be incorporated in the planning and implementation at individual preserves and across the preserve system and ecoregion. The San Diego region should continue to move towards integration of monitoring and management. This will require greater cooperation and coordination to adequately address fundamental challenges (See chapter 3 on Impediments and Solutions for a discussion of the socio-political issues that relate to scale).

A comprehensive and coordinated approach must:

- Identify the spatial scale of monitoring by looking at the scale of threats and natural processes relative to the spatial distribution of the species or natural community targeted for monitoring
- Ensure monitoring efforts across jurisdictions are driven by the spatial scale of the organism and habitat rather than jurisdictional boundaries
- Identify the spatial scale of management actions
- Use and refine conceptual models of target species and biological communities as a way of integrating scale and recommending management actions appropriate for individual preserve areas, the preserve system, or the ecoregion
- Ensure data from the array of monitoring programs are synthesized and analyzed in a timely manner so that insights into emerging trends can be used to alter management actions, funding agencies and management decisions.

Group 2: Covered Species And Ecosystem Function

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The Multiple Species Conservation Program covers a diverse range of taxa (Atkinson et al. 2004, Regan et al. 2006, McEachern et al. 2007, others). The species in the MSCP utilize all habitats found within the Multi-habitat Planning Area, and although each species and site has a unique set of adaptations and habitat requirements/characteristics, some similarities exist. Monitoring all 85 species covered in the MSCP, at every location, is impractical and inefficient. As a result, it is critical to develop implementable goals and objectives, and to prioritize which species and sites should be monitored based on these similarities.

Prioritization should be based on the following factors:

- The ability to address MSCP goals and objectives
- The ability to answer key management questions
- Species 'threatened-ness'
- Ability of land manager to affect change (i.e. minimize threats, enhance habitat etc.)
- The ability to extract information about the ecosystem based on a few measurable factors (such as species presence or productivity)

In addition, the sampling design should be explicit, transparent, reproducible and quantitatively sound. For example important choices must be made about designing monitoring efforts (i.e. random, non-random, complete), which will be driven by project objectives and the spatial and temporal dynamics of the process being monitored (see Group 1)

Species and site prioritization allows monitoring to be carried out and designed efficiently and effectively. For example, hybrid monitoring methods may be applied to a single species at multiple sites. Certain sites may be selected for annual habitat assessment and counting/sampling, and others for time-series (i.e. five or ten year interval) or environmentally-triggered (i.e. high rain year, fire) presence/absence monitoring. Additionally, habitat assessment/sampling protocols may include more than one species at a single site (e.g. vernal pools) for both increased efficiency and comparison of responses of multiple species subject to the same pressures.

The Role Of Single Species Monitoring In HCPs

Single species monitoring is an integral part of successfully implementing a Habitat Conservation Plan. Most plans direct monitoring efforts toward understanding the status and/or trend of individual species. The San Diego MSCP is a good example of such efforts. Monitoring single species that are covered (listed as part of an HCP/NCCP) is a regulatory obligation under the MSCP. In this regard, single species monitoring programs are required. High-quality data collected about single species using appropriate methodology are useful tools in evaluating the success of a plan.

Although single-species monitoring can be informative, monitoring single species may gain the reputation of "monitoring for monitoring's sake." This is particularly true when the monitoring is intended to satisfy a regulatory requirement but its goals and objectives are not well articulated. The lack of clear objectives is compounded with uncertainty from natural background variability and often produces data unable to answer even the most basic questions. Worse, programs may then become data hungry, trying to overcome shortfalls in their design by collecting additional low quality data. These problems have plagued single-species monitoring in the past and need to be addressed as programs move forward (Legg and Nagy 2006, Lindenmayer and Likens 2009).

Many species-specific monitoring programs are based on an early warning framework. Data collected using this framework depends on collecting time series data and searching such data for patterns. When a negative trend is detected, additional research is conducted. Patterns are detected retrospectively, yielding a small return on a program's investment of both time and money. This is because the gain in knowledge may be too late to inform management of any appropriate actions.

Single species monitoring can be productive and integrate well with management programs when conducted in a more predictive framework. Delineating practical questions, relevant to implementing a HCP, that are refined into a set of attainable goals and objectives is critical to the success of single species monitoring programs. Well defined goals and objectives eliminate the ambiguity in the role of a monitoring program and focus energy on capturing natural variability. Testing a priori hypothesis, based on practical questions builds a data framework relevant to understanding basic ecological processes, via a retrospective time trend analysis.

An adaptive approach to management explores alternate ways to meet management objectives by predicting outcomes to alternative management strategies. These predictions are based on current knowledge, and use monitoring data to update knowledge and make rapid adjustments to management actions. Adaptive management is based on a knowledge gaining system, contrary to common thought that adaptive management is based on tracking and changing management actions in the face of maladapted failed policies.

An example of adaptive management at the species level is deciding in which order to reconnect patches of isolated California gnatcatcher habitat. In addition, a single species program can collect data on plant communities. If the program is well considered in the context of the HCP, it can provide information on managing plant communities to protect and sustain resources important to the California gnatcatcher.

Species selected for specific monitoring programs are those that receive a high level of attention. Species that are at a high risk of extinction or local extirpation are candidates, as are keystone species, flagship species, umbrella species, and species targeted by directed management actions. Developing single species monitoring programs for all species covered under a HCP is not practical or efficient given the limitations on budget and time. A prioritization scheme should be put into practice to select what species should be monitored directly.

Ongoing and future single species monitoring efforts should be evaluated in two ways. First, the existing prioritization should be reviewed by local biological experts to assure the rankings are robust. Second, the entire collection of single species monitoring efforts should be evaluated for its ability to assess aspects of broader ecosystem function. If single species monitoring programs provide information about more general aspects of ecosystem status, particularly if slightly modified, or combined with additional information, than perhaps cost savings is possible.

THE CASE FOR INDICATORS

In addition to direct monitoring of prioritized species, indicators can provide a good platform for gauging the status or trend of a system. A wide variety of indicators are used in ecological studies and biological monitoring programs. Indicators can be single species ('indicator species'), groups of species or indexes based on combinations of measurements from multiple taxa.

ASPECTS OF A GOOD INDICATOR

Successful indicators have a number of features that allow their use in monitoring programs. A successful indicator measures characteristics of the biological system, generating information directly tied to management decisions. In monitoring programs, the explicit link between an indicator and variables of management interest should be transparent and based on management objectives. This is straightforward when monitoring a single species, as many statistical methods exist to both design and implement monitoring. However, when management objectives include maintaining broader aspects of an ecosystem, such as ecosystem function, health, or integrity, an empirical relationship between the indicator and what it measures can be less obvious, and thus requires justification.

Since indicators are often abstract or synthetic variables, it is important to define their scales as part of indicator development and validation. This process involves defining what numerical values of the variable indicates "good" or "natural" versus "poor" or "degraded." Often, these values are defined relative to "reference conditions". Reference conditions could be the status of the system in an undisturbed state or in a state preferred by management objectives. Once reference conditions are defined, indicators typically are developed to estimate differences from reference conditions.

In addition to measuring what management objectives dictate, a good indicator should generate the appropriate quality of information at a minimal cost. This aspect of monitoring is often neglected, but has a high pay-offs in long-term programs. 'Fine tuning' indicators and their implementation (field logistics, analysis methods, etc.) can be a multi-year process during which analyses of existing data can be used to inform future monitoring.

EXAMPLES OF INDICATORS

<u>Abiotic:</u> When known relationships exist between abiotic data and management objectives, these data can be used as direct indicators for these objectives. For example, water quality measurements are nearly all non-biological. Other examples of non-biological indicators include soil properties or rates of erosion, disturbance history, time since fire, historical or current land use, and meteorological data. Non-biological data often exist because they are collected by other efforts, but not always. When the biological system of interest is driven by abiotic variables (rainfall, fire, etc.), and these data are not available, the biological monitoring program may have to include these.

Single Species as Indicators: In the MSCP, individual species are a focus of management and have been directly monitored. In such cases, the U.S. Fish and Wildlife Service (USFWS) developed monitoring programs for a wide variety of species. However, species also can be monitored as indicators of overall ecological status (an indicator species), or because the status of one species is correlated with the status of many more (an umbrella species). Both indicator and umbrella species concepts are appealing because they are avenues towards efficient monitoring programs. If a species is to be used as an indicator of multiple species or ecosystem function, the strength of the relationship(s) should be strong and well documented.

Community Level: Similar to single species, groups of species can be combined and their overall richness, diversity, or abundance used as an indicator. Examples include fish assemblages, bird communities, native plant diversity, and diversity of beetles or ants. These metrics are appealing since they are fairly simple and have been discussed in the scientific literature. Two important drawbacks are the variety of ways diversity can be calculated (Richness, Shannon-Wiener, Simpsons etc) and the reliance of these indices on highly-trained staff. Measures of diversity are sensitive to the correct identification of many rare and/or cryptic species and may not be well suited to large monitoring programs with high staff turnover.

Index-Based: Index-based measures were developed to estimate characteristics of complex systems, which have too many individual components to measure each at once. Examples include the Dow Jones Industrial Average, or the Index of Leading Economic Indicators, used to estimate characteristics of the entire US economy. Indices of biological integrity (IBI) have been successfully developed and used, particularly in fresh water streams. Sometimes index-based methods are derived from community level-data, making them easier to implement. For example, bird point count data has been used to derive indices by sub-setting and combining the bird community data in unique ways (Diffendorfer et al. 2007).

Landscape-Focused: Remote sensing and GIS technologies allow monitoring using imagery from satellite or airplane mounted sensors. Historically, images represented infrequent snapshots of a large region, but new technologies now allow change detection by comparing high-resolution images taken at different time periods. In addition, new sensors are beginning to allow refined compositional analyses of vegetation communities. As with all indicators, the challenge to harnessing these technologies is to define the relationship between measureable indices and important components of ecosystem function relevant to conservation management.

Possible indicators for the MSCP

An impressive amount of research with direct implications for the development of indicators in the MSCP has already taken place. These include direct tests of gnatcatchers as indicator species, post-fire vegetation studies, sampling taxa across gradients of exotic invasion, studying co-occurrence patterns in herpetofauna, studies of urbanization and fragmentation effects, studies of disturbance and fire on exotic plant invasions, and studies of remote sensing methods in Southern California vegetation communities. Collectively, our group identified 4 indicators to consider further for monitoring in the MSCP.

- Remote sensing based indicators of vegetation change. Coulter and Stow (2009) evaluated the usefulness of high resolution imagery for monitoring and concluded "Land cover changes relevant to habitat quality monitoring such as human induced disturbance, fire, vegetation growth/recovery, and drought related vegetation stress were readily detected using the multitemporal VNIR imagery."
- A Coastal Sage Scrub vegetation index. A rich literature exists on both CSS responses to disturbance, including fire, and the role CSS plays in supporting a wide variety of animal species. Thus, indicators associated with CSS composition (relative cover, species composition) and structure (shrub height, litter depth, bare ground) will likely be correlated with the co-occurrence of other species.
- Exotic cover. Though levels of exotic cover vary annually based on rainfall, exotic cover is negatively correlated with CSS cover in a number of studies and indicative of a loss of shrub requiring species.
- A bird community-based metric for CSS and Chaparral. A number of studies suggest unique assemblages of birds respond to urbanization gradients and gradients of exotic cover. Since birds can disperse large distances, their presence across the landscape may indicate habitat suitability.

Issues for indicators in the MSCP

CSS and chaparral vegetation communities are dominant in the MSCP. CSS and chaparral are relatively well studied and indicators of ecosystem status are likely viable for these systems (but see next paragraph for issues). The MSCP, though dominated by CSS and Chaparral vegetation, includes 16 vegetation types as defined by Regan et al. (2006). These vegetation types represent unique ecosystems, often in highly fragmented locations, and some support particular covered species. In these less common vegetation types, we may not have enough information to implement indicators that best meet management objectives because data on reference conditions or response of the system to stressors does not exist. In these cases, options include developing indicators based on professional opinion and literature review then updating as new information is gleaned (a multi-year process).

For CSS and Chaparral vegetation types, Chase et al (2000) found that indicator species of conservation concern in CSS could not be assumed to be indicators of hotspots for either bird or small-mammal richness. Furthermore, in their examination of 40 species of birds and mammals the presence of bird and mammal species were poorly correlated, suggesting that managing for a single species would not result in effective conservation planning. This study indicates use of single species as indicators or as umbrella species may not be an effective approach for the shrub-dominated vegetation types in the MSCP. However, single species approaches may be effective in other vegetation types. As noted above, single species monitoring efforts currently exist in the MSCP, which have not been evaluated for their potential as indicator or umbrella species. Finally, large datasets on communities of organisms exist. Examples include a suite of bird point count data and herpetological pitfall trap data. Large datasets like these should be more fully analyzed in the context of monitoring.

Integration, synthesis, and synchronization of indicators

Indicators chosen for use in the MSCP should not be considered in isolation. Integration can occur in sophisticated ways. For example, vegetation monitoring could take place at large spatial scales using remotely sensed methods and at much finer scales using plot based methods. If plot based methods were collected in a manner that allowed statistically linking these data to the remotely sensed data, a variety of benefits accrue. First, prediction of vegetation status and change from the remotely sensed data can be improved via modeling based on the field data. Second, individual plant species or vegetation cover models could be developed, allowing the extrapolation of field based plots to larger scales. Third, as the relationships are tracked through time, field-based data may not need to be collected as frequently, reducing overall costs.

Translating Monitoring into Management

Feedback Processes

Some of the fundamental challenges to designing effective management and monitoring programs are how data are archived and analyzed, and whether results from these analyses are used to inform and improve future monitoring and management.

Lack of uniform data collection and lack of resources for data archiving are two key issues that need to be resolved. Monitoring protocols have been established for a number of species and communities of conservation concern in the MSCP (Ogden 1996, USFWS 1999, 2001, 2002, 2005). Yet, these are not uniformly employed at the preserve levels. Likewise, limited personnel resources often preclude the establishment of tractable and accessible databases and timely data archiving. Finally, limited personnel and expertise impedes the ability to adequately analyze data collected. Without formal results, collected monitoring or post-management action data are rarely used to improve monitoring protocols or evaluate management strategies (Kull et al. 2008, Ferretti 2009). This disconnect between data collection and activities in the field, whether it is monitoring or management, represents one of the most substantial obstacles to best-practices approaches of preserve management (Whitacre et al. 2007, Kull et al. 2008, Marsh and Trenham 2008, Schmeller et al. 2008, Fancy et al. 2009). A more powerful use of monitoring data and subsequent statistical analyses is to integrate them directly into a chain of adaptive monitoring and management decisions.

Completing the circle between monitoring, data analysis, and management strategy assessment creates an iterative feedback loop that allows for critical review of each component of the process (Atkinson et al. 2004). For example, using this approach, managers can decide how to allocate resources among monitoring efforts, based not on the statistical precision in individual point estimates, but on the precision of a comprehensive analysis of all monitoring information. This iterative, feedback loop may require resources (technical, personnel, etc.) that are not currently available to most MSCP reserve managers. Partnerships that pair reserves with institutions with the capacity and expertise may be one solution to these resource limitations. To ensure that limited resources for monitoring and management are used most effectively, we suggest that this integrated process is a priority for the MSCP.

Sharing Results

Once robust data have been collected, reviewed and summarized, it is imperative that it is distributed to land managers. The data will be used most effectively if land managers work jointly to address issues identified through monitoring.

Section 5.8 of the MSCP indicates that the participating jurisdictions will create two coordination committees, a Habitat Management Technical Committee and an Implementation Coordination Committee, to address preserve management and implementation issues on a sub-regional or region-wide basis. Although these committees formed and met in the past coordination among land managers does not go far enough to facilitate seamless information sharing and effective coordination of monitoring and management actions for reserves.

This need may be partially met by coordinated working groups which exist in formal structures such as regular intra- and interagency meetings and the *TransNet* -funded Environmental Mitigation Program. Typically, there are regulatory drivers for these regular interactions among agency management and staff, permittees, researchers, non-governmental organizations, and the public. But these types of meetings (e.g. NCCP Manager's Meeting) may not meet as often/regularly as desired or needed without dedicated individuals/groups who maintain the meeting's structure and organization.

Another avenue for land manager coordination are ad hoc working groups developed by individuals or groups who identified issues and sought out others with like concerns. These groups are also characterized by the willingness of one or more people to organize and sustain the group's interest. It takes a great deal of effort – often outside the individual's regular job duties – to schedule, develop agendas, take and transcribe notes, keep records of attendees, disseminate information, and receive feedback to make and keep these groups running.

Strengths of working groups include a focused purpose for species-, area-, or topic-specific meetings and the ability to share or hear from others you may not work with frequently (or at all). Drawbacks include the haphazard scheduling of these meetings, inability to share the information with a larger audience (regional, cross region) given the lack of a structure to store and/or disseminate that information.

We believe the current working group model contributes to effective and efficient monitoring and management, and recommend updated MSCP monitoring methods/plans that increase the capacity of working groups to form, to exchange information among and outside the group, and to sustain the group so that it remains useful to the participants.

Some of the working groups in San Diego, Orange, and Riverside Counties are shown in the tables below (Tables 6 and 7).

Summary

In all likelihood, funding will never allow direct monitoring of the entire suite of species, habitats, or ecosystems in the MSCP. However, indicators that maximize the information generated may exist. One way to do this is to design a suite of indicators that can be linked in more comprehensive analyses. For example, knowing the status of a single species is noteworthy, but if additional data on burn perimeters, vegetation status, and rainfall allow robust predictions of the species distribution and abundance, a much richer picture emerges about what factors affect the species and what management actions might maintain its populations.

Table 6:Formal NCCP monitoring and management coordination groups in San Diego, Orange, and Riverside Counties

Group Name	Meeting Schedule	Attendees	Discussion Level (Preserve, Region, Cross Region)
NCCP Managers	Quarterly	Wildlife Agency managers and staff	Region, Cross Region
TransNet Environmental Mitigation Program Group	Monthly	Agency staff, jurisdiction staff, NGOs and others	Region
MSCP Annual Workshop	Annually	Agency staff, representatives from many jurisdictions, NGOs, and the public	Preserve, Region
Tijuana River (TRNERR) Advisory Council	Monthly	Agency staff, public	Preserve
San Diego Management and Monitoring Program	Monthly	Program administrators, land managers, jurisdiction staff, researchers	Preserve, Region, Cross Region
Wildlife Agency Internal Meetings	Monthly	Agency staff	Preserve, Region, Cross Region
Wildlife Agency with Permittees	Monthly/Annually	Agency staff	Preserve
SD County Weed Management Area	Ad Hoc	Agency staff, NGOs, public	Region
San Dieguito Invasives Management Group	Ad Hoc	Agency staff, NGOs, public	Region
Western Riverside MSHCP Managers	Monthly	Agency staff, researchers, invited guests	Preserve, Region
Nature Reserve of Orange County Science Advisory Comm.	Monthly	Agency staff, researchers	Preserve, Region

Table 7: Informal NCCP monitoring and management coordination groups in San Diego, Orange, and Riverside Counties

Group Name	Meeting Schedule	Attendees	Discussion Level (Preserve, Region, Cross Region)
MSCP Monitoring Group	Monthly	Agency staff, USGS	Preserve, Region
South County Land Managers	Quarterly	Land managers	Preserve, Region
North County Land Managers	Quarterly	Land managers	Preserve, Region
Acanthomintha Working Group	Semiannually	Land managers, agency staff, researchers	Preserve, Region, Cross Region
Riparian Bird Working Group	Annually/ Biannually	Agency staff, USGS, contractors	Preserve, Region, Cross Region
Least Tern Working Group	Annually	Agency staff, USGS, contractors	Preserve, Region, Cross Region
Snowy Plover Working Group	Annually	Agency staff, USGS, contractors	Preserve, Region, Cross Region
Vegetation Monitoring Group	Ad hoc	Agency staff, researchers	Preserve, Region, Cross Region
Cactus Wren Working Group	Ad hoc	Land managers, agency staff, researchers	Preserve, Region, Cross Region
Tecate Cypress Workshop	Ad hoc	Invited attendees	Cross Region
Burrowing Owl Workshop	Ad hoc	Invited attendees	Cross Region
Hermes Copper Workshop	Ad hoc	Invited attendees	Cross Region

GROUP 3: IMPEDIMENTS AND SOLUTIONS

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OVERVIEW

Creation, monitoring, and management of reserve systems for the protection of native species and ecosystems requires collaboration among multiple stakeholders from a wide range of government, non-government, academic, and private organizations. Differences among these participants in how they influence or are influenced by group decisions can both enhance collective efforts and impede them. We identified a list of impediments to implementation of a reserve-wide monitoring and management strategy based on experience with current practices. We develop further several of the issues that the group considered to be the most important impediments to effective cooperation. We then constructed a model for implementation that seeks to incentivize participation in collaborative planning and management networks, focusing on components with the highest solvability. Many of the obstacles identified by our group were recognized as outside the scope of high or immediate solvability; these will warrant further attention in future considerations.

IMPEDIMENTS TO IMPLEMENTATION OF THE MSCP MONITORING AND ADAPTIVE MANAGEMENT PLAN

We identified the lack of a strategic plan as an obvious deterrent to coordinated action, and while the group agreed to focus attention on potential impediments to the future implementation of an adopted plan, it should be recognized that monitoring and management are occurring today, and in a loosely coordinated manner. The remainder of our discussion assumed the completion of a monitoring and management strategy in the future, and considered potential impediments to that plan. Our comprehensive list of impediments is listed in Table 8.

Table 8: Comprehensive list of impediments.

#	Description	Priority, Solvability
1	Lack of an approved strategic plan, based on science, for reserve-wide (and ultimately ecoregional) monitoring and management.	High priority **and** potentially solvable
2	Lack of a centralized database and information system that allows access to data and products that can inform MSCP monitoring and management.	
3	Funding challenges, such as inadequate funding levels, systems by which funding is allocated internally and externally to management organizations, and restrictions on uses imposed by funders.	
4	Poorly defined roles and responsibilities of participants in a leaderless, de-centralized cooperative network, which leads to poorly-defined decision-making processes.	
5	The dual focus of many agencies on both land acquisition and management, which hinders their ability to advance development and implementation of a strategic plan.	Lower priority **and/or** not solvable by this group
6	Lack of coordination among land managers on best management practices.	
7	Intra- and inter-agency differences in mandate, priorities, goals and objectives, jurisdiction ("turf"), power, and authority.	
8	Turnover of staff/participants, which may result in loss of institutional memory and expertise and affect the levels of executive support in Sacramento and Washington D.C. for regional conservation planning and implementation processes.	
9	Inability or unwillingness of participants to recognize the distinction between regional versus preserve-level issues, and to shift perspective accordingly.	
10	Fear of loss of jurisdictional authority and/or autonomy.	
11	Delays and inefficiencies in regulatory agency permitting processes that authorize monitoring and management activities involving listed species.	
12	Negative public perceptions regarding the utility of monitoring and management of conserved lands	

Key Issues Impeding Effective Cooperation and Potential Solutions

We identified impediments 1-4 in Section II as key issues with the highest potential for solvability. In this section, we examine each one in greater detail and recommend potential solutions for overcoming these obstacles.

LACK OF A STRATEGIC MONITORING AND ADAPTIVE MANAGEMENT PLAN (STR-MMP)

Description: Currently, there is no agreed upon, comprehensive Strategic Monitoring and Adaptive Management Plan (STR-MMP) to guide implementation of a monitoring and management strategy for the MSCP. In the absence of such a plan, monitoring and management activities tend to be carried out independently between land management agencies and other stakeholders across the MSCP, resulting in gaps in implementation, redundancies, inefficiencies, and uncertainties.

Discussion: A comprehensive strategic STR-MMP, informed by sound science, is essential to monitoring and management in and of itself, and is also essential for clearing other impediments to successful implementation of the MSCP. Such a plan would involve regulators and implementers in its development, thereby greatly clarifying the MSCP's monitoring and management approach, and ensuring that key stakeholders are all cooperating toward effective conservation of covered species and the habitats and ecological processes upon which they depend.

Elements of the Strategic Plan:

- **Collaboration:** The STR-MMP would require buy-in from stakeholders at all stages of its development, from establishing goals and objectives to identifying roles and responsibilities for successful implementation. The planning process should involve the people and agencies who will be responsible for implementing the plan. A cross-functional planning team (representatives from each agency and function) should be formed to ensure the plan is realistic/feasible as well as collaborative.
- **Goals, Objectives and Responsibilities:** The STR-MMP should outline clear and explicit goals and objectives of the MSCP monitoring and adaptive management program. It should also specify and clarify the roles and responsibilities for each of the agencies participating in plan implementation, and include a timeline for implementation.
- **Communication:** The STR-MMP should include regular communications on implementation status through an organization such as the San Diego Association of Governments (SANDAG) that can efficiently disseminate the plan to, and receive input from, stakeholders and the public. Effective communication of the STR-MMP will ensure transparency and encourage buy-in.
- **Organization:** The body of the STR-MMP should lay out the goals, objectives to meet the goals, strategies, roles and responsibilities, implementation plan and a monitoring/evaluation feedback loop. The STR-MMP appendices should include more detailed elements of the plan or items that might change over time, including specific “Action Plans” for monitoring and management of particular species, habitats, land management units, ecological processes, or administrative processes (e.g., maintenance of the information system, evaluation of management actions for funding).
- **Flexibility, Accountability and Autonomy.** The Action Plans for monitoring and management should not be entirely prescriptive but rather provide a range of options for achieving monitoring and management objectives. This will allow land managers and agencies some flexibility in implementing aspects of the STR-MMP under their purview, so they can operate within their own organizational constraints, or choose a management action based on firsthand knowledge of the land and habitat they manage. However, the body of the plan should be

specific in detailing responsibilities of plan participants and timelines for implementation. In this way, the different agencies responsible for implementation can maintain their autonomy while contributing to the successful implementation of the plan.

- **Incentives for Collaboration:** While it's important for the STR-MMP to maintain autonomy for participating agencies, it is equally important for agencies to collaborate on implementation of strategies and actions. The STR-MMP should provide incentives for cooperation. For example, collaborative projects involving multiple agencies and/or multiple sites might receive priority for regional funding.
- **Evaluation:** The STR-MMP should incorporate regular reviews to assess whether actions are meeting established goals and objectives. In this review process, feedback from the scientific monitoring program should be used to evaluate the success or failure of strategies/actions in meeting stated goals and objectives. If goals and objectives are not being met, strategies and actions may be revised to increase the likelihood of meeting the goals. However, if goals and objectives are being met, and are likely to remain so with little or no additional management, goals and objectives may be reformulated to focus resources and management actions on previously unmet needs. Goals and objectives may also change in response to new scientific information pertaining to prioritization of conservation of species, habitats, land management units, or processes.

<u>Recommendations and Next Steps:</u> Create a STR-MMP to provide a scientifically-based, consistent, and standardized process for addressing regional and preserve-level monitoring and management needs and issues, as well as answering specific questions regarding biological resources within the MSCP. This plan would provide the framework to (1) assess whether preserve lands are adequately protecting resources for which they were designated and (2) determine when adaptive management is needed where resources are declining.

Key components of a STR-MMP should include resource-specific monitoring protocols and adaptive management methodologies (the latter based on Best Management Practices [BMPs]). The STR-MMP should include a range of management options; land managers would select the most appropriate option(s) for their land from this pre-approved list or 'menu' of available methodologies. Although the predominant resources to be addressed in the STR-MMP would be those covered under the MSCP, the plan would provide the flexibility to allow monitoring and management of additional (non-covered) sensitive biological resources. The STR-MMP should address both species-specific and habitat-based monitoring and management needs.

Lack of a Centralized Information Management System

<u>Description:</u> Currently, there is no single system to store, retrieve, analyze, and display information on the location and results of monitoring and management efforts in the region. This lack of a publicly accessible, up-to-date system has resulted in a loss of information, duplicative efforts, lack of analyses and feedback between monitoring and management actions, and the inability to provide information to the public and other researchers.

<u>Discussion:</u> Although we focused our discussions primarily on the MSCP, it is useful to consider the broader San Diego region in developing a centralized data management system. For example, there are two approved NCCPs in San Diego County and two more in preparation. The reserves assembled as part of these plans will likely be nearly 500,000 acres within the nearly 3 million acres that comprise San Diego County. It is anticipated that when the plans are completed, the conserved lands will provide for

the conservation of 150 or more species, and will be managed by 30-50 different entities, including local, state and federal agencies and non-profit organizations. As a result of both the large number of species and reserve managers implementing a wide variety of adaptive management actions and the continued regional monitoring efforts for species and habitats, there is a need to (1) analyze the best solution for a database that can satisfy the regions' needs and is compatible with other federal and state database efforts and (2) develop procedures to populate the databases and facilitate storage, analysis, and integration of proposed regional monitoring and adaptive management activities. While some databases currently exist, there is no single information management system.

Identified Needs: The key needs for a centralized information management system are:

- Develop an information management system that links into a central system that provides information. This system would go beyond a traditional database or geospatial database to allow easy access to compiled data, as well as source documents such as PDFs of reports and field forms in a digital library system.
- Link existing databases in this information management system. Multi-taxa, BIOS, SANBIOS, CNDDB and SANGIS all house information in various formats. These databases need to be linked to optimize the efforts that have been expended to create them. It was noted that these databases need not be required to be in one database, as long as their information could be accessed through a single portal type of system.
- Develop a "filter" or mirror server that allows data to be accessed by the public. Currently, access to some information is not readily available and information sharing is arduous. Lack of accessible data hampers public review and third party data analysis.
- Identify the types of information required to make monitoring and management decisions. A future information management system should address the decision-making needs of its users versus capturing data for the sake of data collection.
    - What queries are wanted from the data?
    - What are the minimum attributes that need to be collected?
    - What are the optimum attributes that need to be collected?
    - What can be accomplished in the short-term versus trying to build the "ultimate" information system?
- Identify dedicated staff and funding to develop, maintain, update, and enhance the information management system.

Existing Efforts: The U.S. Fish and Wildlife Service is currently coordinating with the U.S. Geological Survey and California Department of Fish and Game and the San Diego Management and Monitoring program (SDMMP) on database development. These entities have significant investment into databases that need to be coordinated. SANDAG, also a large supplier of spatial data, has provided supplemental funding towards a position to work with SDMMP and regional, state, and local stakeholders to determine database needs for monitoring species and habitats and adaptive management efforts.

The USFWS is tasked with the following:

- Preparing a report that will review existing databases and determine the best approach to meet regional needs through either augmentation of an existing database, creation of a new stand-alone database, or another structure that meets regional needs. The report will address both the ease of incorporating existing data into the database, the ability to analyze data once in the database, and the restrictions (if any) on making data available to the public. The report will also examine the location of the database server and restrictions associated with access and input from various users.
- Collaborating with the SDMMP team to identify key fields for the regional monitoring and adaptive management database that are compatible with other databases (e.g., multi-taxa database), field testing the applicability of the data fields, developing data sheets that capture needed information, training land managers and other contractors conducting regional and preserve-level monitoring in the use of the data sheets, and assisting in populating the database.
- Collecting data for incorporation into a database structure that includes existing digital data and data provided by the SDMMP.

Recommendations for Next Steps: In order to implement a centralized information management system it will be necessary to reach a consensus on the types of information needed the system. This includes identifying access by regulators, scientists, and the public. It will be important to identify funding needs for developing, maintaining, and updating a centralized information management system.

LACK OF ADEQUATE FUNDING FOCUSED ON MSCP MONITORING AND MANAGEMENT

Description: The MSCP, along with other Natural Community Conservation Plans (NCCPs), has been criticized for failing to identify secure funding mechanisms for plan implementation. This is especially true for sustained long-term funding for monitoring and management of species and habitats within assembled preserve systems. If funding sources are not identified and strategically applied to carry out monitoring and management of preserves, these plans are in danger of failing to provide for conservation of regional natural resources as originally envisioned and touted. The lack of identified funding for monitoring and management above and beyond what can be provided by land managers is beginning to diminish the willingness of land managers to take on additional properties or of jurisdictions to adopt additional plans.

Discussion: The expectation has been that the land managers will provide the necessary funding for monitoring and management; however, these programs and activities do not compete well for funding given the mandates, objectives, and fund use restrictions of the various jurisdictions and agencies. Further, public perception is that additional funding is not warranted for these activities, particularly in light of current economic conditions. A major problem is that the true cost for fulfilling monitoring and management commitments has not been determined nor adequately communicated to the public and elected officials. While efforts to elicit support for short-term funding are relatively successful and achievable, sustained support for long-term funding is more difficult to obtain and maintain given the frequent redirection of governmental priorities.

Currently, land managers and jurisdictions are applying some portion of their annual budget allocations to monitoring and management of covered species and preserve lands, and are looking to a regional funding source, such as SANDAG's *TransNet* funding, to fill the gap. Another regional funding source, the Quality of Life Initiative, is being pursued to provide sustained long-term funding for local jurisdictions.

Regardless of the amount of funding available now or in the future, we recognized that applying those funds effectively and justifiably will need to be addressed, and we discussed various means by which to determine fund allocation to best achieve monitoring and management of the preserve system, including:

- Some type of formula-based distribution of funds to each jurisdiction to provide predictability.
- Allocation of funds based on strategic adaptive plan objectives and triggers.
- Allocation of funds to identified key management issues wherever they occur.
- Some combination of allocation schemes to achieve both flexibility and predictability.

Identified Needs:

- Accurate cost estimates of required monitoring and management tasks.
- Effective means of communicating funding needs to the public and elected officials.
- Allocation scheme for applying limited funding to monitoring and management activities.

Existing Funding Sources:

- Land Manager annual budget allocations (various original sources)
- Interest from Mitigation Endowments for specified lands
- SANDAG/ *TransNet* Grants
- Federal and State Grant Programs
- Philanthropic Grant Programs/Donations

Recommendations for Next Steps:

- Develop monitoring and management cost estimates based on the STR-MMP.
- Develop a funding allocation scheme based on the STR-MMP and cost estimates for implementation.
- Develop a public outreach 'story' regarding monitoring and management funding needs.
- Lobby for long-term funding mechanisms at the federal and state level. Collaborate with the California Habitat Conservation Planning Coalition to advocate for Statewide commitment of resources to NCCP plan implementation, specifically long-term management of assembled preserve systems.

Lack of Defined Roles and Responsibilities of Participants

Description: The roles and responsibilities of agencies and organizations involved in implementation of the MSCP are varied. The wildlife agencies' role is to assure conservation of covered species through implementation of the MSCP, while the role of jurisdictions and others with Habitat Conservation Plans (HCPs) is to implement conservation actions articulated in the MSCP plans and Implementing Agreements. "Other organizations" assist in designing and implementing monitoring and management actions and provide oversight/review of the wildlife agencies' actions. Under the MSCP, some of these roles are unclear or narrowly defined, resulting in intra- and inter-agency conflicts. For example, the USFWS plays a role as regulator, land manager, and coordinator of conservation efforts; while some non-governmental organizations manage lands and provide technical assistance in implementing the MSCP.

Discussion: Because the MSCP lacks clear monitoring and management goals and objectives, the wildlife agencies have no specified metrics for evaluating compliance and assessing the success of conservation under this program. Currently, the lack of clearly articulated goals and measurable and quantifiable objectives necessitates the direct involvement and approval of the wildlife agencies in nearly every decision regarding monitoring and management. It is only through this involvement that the agencies can fulfill their role of assuring conservation under the MSCP. This constant and pervasive oversight can lead to (1) redundancies by forcing similar projects from different managers to go through the same evaluation process, (2) delays during the review process due to limitations of staff availability within the wildlife agencies, (3) a potential for lack of consistency as personnel change within agencies and organizations, (4) confusion for land managers in identifying projects that will be reviewed against unstated or changing priorities, and (5) a micro-management scenario that depresses the sense of ownership and creative solution approach of individual land managers.

Overall, the lack of a STR-MMP with clear monitoring and management goals and objectives has contributed to a system whereby:

- Roles and responsibilities of organizations have been confused.
- Each monitoring and management action must be proposed for approval by multiple organizations that may or may not have a vested interest in the project.
- The approval process for proposed projects can be lengthy due to multiple levels of review and the need for regulatory agency concurrence, and the process lacks the ability to respond rapidly to an emerging crisis.
- There is a lack of consistency in determining when and how proposed projects are submitted for scientific review (again, roles are unclear as to who provides review).
- It is unclear how individual projects contribute to an established goal or objective; thus, hindering the ability to assess success of the MSCP (*note: this is not to say that projects approved to date lack merit. To the contrary, most projects have been helpful at forwarding conservation of a single species or community, but without a larger context of goals and objectives it is difficult to assess where those projects fit in and if the overall monitoring and management program of the MSCP has been successful).
- Permittees lack assurances that monitoring and management actions are providing incremental benefits and are consistent with their commitments under the MSCP.

Identified Needs: A STR-MMP with clearly articulated goals, quantified and measurable objectives, and specific implementation strategies would ensure that roles and responsibilities of agencies and organizations are closely aligned. For example, if the wildlife agencies could rely on STR-MMP goals and objectives as metrics for evaluating compliance and success of the MSCP, they would not need to participate in every decision. Likewise, the STR-MMP would provide agencies and organizations with approved HCPs and land managers with a clear understanding of responsibilities and a set of approved strategies (management actions) that could be implemented without further review.

Recommendations for Next Steps: The key next step is to clearly define roles and responsibilities for participants involved in implementation of the MSCP process (Table 9).

Table 9: Roles and responsibilities of different organizations in monitoring and management.

	USFWS – Regulatory	CDFG – Regulatory	USFWS – Refuges	CDFG – Land Mgmt	SD County	Cities	CA State Parks	NGO Land Managers	SANDAG	Science Support [1]	Other interested parties [2]
Interpret and Clarify Enabling documents	R	R			R	R			I		
Review and Assure Permit Compliance	R	R			R	R					
Develop Management Goals and Objectives	R	R	V	V	R	R	V	V	I	I	V
Develop Monitoring Goals and Objectives	R	R	V	V	R	R	V	V	I	I	V
Develop Management Strategies	I	I	R	R	R	R	I	I		I	V
Develop Monitoring Strategies	I	I	R	R	R	R	V	V	I	R	V
Periodically Assess Regional Level Management Needs	I	I	R	R	R	R	R	R		V	
Periodically Assess Preserve Level Management Needs	I	I	R	R	R	R	R	R		V	
Develop Funding Request(s) for Regional Management Needs	V	V	R	R	R	R	R	R	V		
Develop Funding Request(s) for Preserve Level Management Needs	V	V	R	R	R	R	R	R			V
Review Prioritization of Local and Regional Funding Requests	V	V	R	R	R	R	R	R	I	R	
Authorize/Allocate Regional Funding	V	V							R		
Authorize/Allocate Reserve Level Funding			R	R	R	R	R	R			
Implement Management Actions			R	R	R	R	R	R		V	
Implement Regional Monitoring			I	I	R	R	I	I	I	I	V
Implement Preserve Level Monitoring			R	R	R	R	R	R		I	
Review/Assess Regional Monitoring Results	R	R	I	I	R	R	I	I	I	I	V
Review/Assess Preserve Level Monitoring Results	V	V	R	R	R	R	R	R		I	V

Organization Responsible (authorization required for task to proceed)	R
Organization that shall be asked to provide Input (but no authorization required)	I
Organization that may Volunteer and provide input (scientific, technical or general input)	V

Conceptual Model for Regional Monitoring and Management Decision Structure

We synthesized our ideas on how to overcome some of the major impediments to plan implementation and created a model for cooperative decision-making based on participant roles and responsibilities (Figure 7). While this model is specific to the MSCP, we believe it provides a framework that can be adopted for future plans, and that will integrate multiple plans into a regional cooperative network. We recommend employing existing and emerging groups as much as possible to serve the identified functions of the model, rather than establishing new entities. Key elements of this model are described below.

Plan Creation and Function: We envision that creation of the STR-MMP would be under the purview of SANDAG, with collaboration from major jurisdictions and agencies. The STR-MMP would be created by a consultant selected by a formal technical committee (e.g., SANDAG Environmental Mitigation Program [EMP] working group), with input from agencies and scientist representatives. The plan would be reviewed at several stages of its development. Technical review would occur by the formal technical committee, the wildlife agencies, and the SDMMP; the plan would also be subjected to review by independent scientists (e.g., Scientific Advisory Panel) and other scientists familiar with the resources involved. In addition to the technical review, the STR-MMP would be reviewed by the SANDAG management steering committee, consisting of the Deputy Chief Administrative Officer for Land Use from the County, the City of San Diego Director of City Planning, regional leaders for the USFWS and CDFG, and the Executive Director of SANDAG.

Although the organizational structure of the MSCP is decentralized, the STR-MMP would provide a centralized foundation and assure that while each entity retains autonomy, its actions are consistent with the goals of the program and compatible with the actions of other MSCP land managers. Individual land managers would use the strategies and prioritization within the STR-MMP to guide monitoring and management actions on their lands, irrespective of the funding source. If land managers propose to use a regional funding source for a project, they should review STR-MMP strategies and prioritization before preparing the proposal, effectively reducing review time and providing greater assurance of approval.

Plan Approval: The STR-MMP would require approval by the wildlife agencies, the formal technical committee, a formal representative committee (e.g., SANDAG EMP, SANDAG Planning Committee with Wildlife Agency representatives), and the SANDAG Board of Directors. Individual jurisdictions may wish to officially review and approve the STR-MMP prior to SANDAG Board approval. Future modifications to STR-MMP goals and objectives, which form the basis for evaluating regulatory compliance, would require wildlife agency approval.

Land Manager Coordination: Establishment of Geographically Coordinated Management Areas (GCMAs) would maximize monitoring and management efficiencies, reduce redundancies, foster cooperation across jurisdictional boundaries, and leverage funding opportunities for managed lands within preserves. Within GCMAs, land managers would be encouraged to work together to create and implement coordinated strategies for monitoring and management. Land managers would participate in sub-regional committees (e.g., the South County Land Managers Group) to share experiences and knowledge of land management techniques, identify cross-boundary needs, and develop/review projects proposed for regional funding. Through this process, cohesive strategies to address key monitoring and management issues would be identified, funded, and implemented across a sub-region.

Prioritized List of Projects: Land managers within GCMAs would collaborate to create a prioritized list of monitoring and management projects for their sub-region, based on goals and objectives, resource-specific needs, and management options identified in the STR-MMP. Projects on the list may address an individual preserve or multiple preserves, as well as individual or multiple species or habitats. All interested parties could attend sub-regional committee meetings and provide input; however, only land managers would vote on projects to be included on the list. The project list would be in place for a determined period of time and would be updated on a specified schedule.

Project List Approval Process: The project list for each GCMA would be reviewed by the formal technical committee and independent science advisors (e.g., USGS or other specialists). Upon approval, the project list would function similarly to a 5-year strategic plan. The process would also establish a contingency mechanism to address unexpected and emergency projects that were not included in the initial project list. This contingency mechanism would require review by the formal technical committee and approval from the SANDAG Board.

Funding Process: Within a given grant cycle, sub-regional committees within each GCMA would forward proposals consistent with their priority project list to a regional monitoring and management committee for funding consideration under the *TransNet* EMP (or other regional funding entity). The regional monitoring and management committee (consisting of a representative from SANDAG, as well as one representative from each sub-region) would prioritize proposals within each sub-region based on need and consistency with the project list; prioritized proposals would then proceed through the SANDAG Planning Committee and SANDAG Board for approval and funding. The process for release of funds would be determined by the SANDAG EMP management process (potentially, a guided process for particular regions, species, or habitats). Both sub-regional and regional committees may seek input from independent science advisors or the wildlife agencies regarding proposal development or review.

Grants sought by the land managers from other sources may also proceed through this process. If a land manager has obtained alternative funding, the approval process through SANDAG would be unnecessary; however, it would be desirable for all monitoring and management projects to follow STR-MMP concepts. At a regional level, the goal would be for monitoring and management funds to be directed towards priority projects within GCMAs.

As part of the funding process, a percentage of each year's allocated funding should be held in reserve as contingency funding by the regional monitoring and management committee for emergency needs, allowing for a rapid response to emergencies arising from unforeseen events (e.g., fire).

Closing the Adaptive Management Loop: Results from funded monitoring and management projects would be collated by a regional monitoring and management coordinator, such as the SDMMP, and used to assess progress towards achieving STR-MMP goals and objectives, and to inform adaptive management needs. This information would then be forward to the project implementer as well as other land managers.

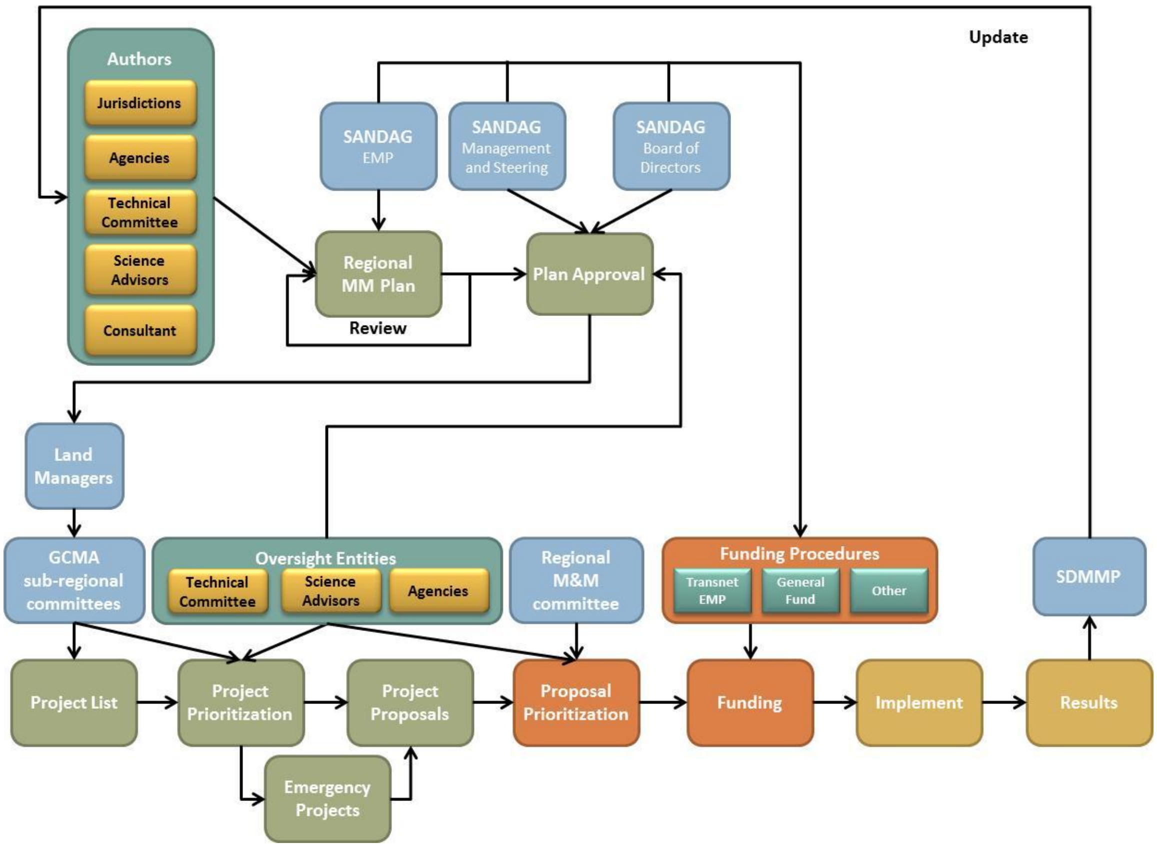

Figure 7: Possible regional monitoring and management decision structure.
This figure suggests one model for the organization of activities.

SUMMARY

Although it is clear from the preceding discussion that some impediments will be amenable to straightforward mechanistic solutions, we recognize that even the simplest solutions will require a great deal of time and effort. We further acknowledge that other impediments will require solutions that are outside this group's ability to conceptualize and perhaps any group's ability to implement. Nevertheless, we feel the identified impediments accurately represent the existing challenges to MSCP implementation, while the recommendations provide workable solutions that can be accomplished within a reasonable timeframe.

We view the following components as necessary to successful implementation of regional monitoring and management within the MSCP:

- A science-based, stakeholder-informed Strategic Monitoring and Adaptive Plan (STR-MMP).
- A centralized database to allow more complete and timely information flow between the parties regulating and implementing the MSCP.
- A funding process that is transparent and promotes sub-regional collaboration.
- Clearly defined roles and responsibilities of plan participants, resulting in streamlined approval processes and assurances to stakeholders that funded actions are achieving their objectives.

AFTERWORD

Keith Greer, Senior Regional Planner, SANDAG

In March 1997, a core group of representative researchers and land managers from differing south California regions, sectors, and perspectives gather together to advise the State of California Natural Communities Planning (NCCP) program on methods for developing and disseminating ecological information needed for planning and management. This core group drafted a guidance document entitled Research Guidance to Address the Needs of Land Managers (Stine, P. 1997).

Through a series of working meetings, the group reached consensus that established the fundamental direction for early research to assist land management efforts in San Diego County. Fifteen years later a coordinated approach for the integration of science into management for efficient decision making still remains a challenge; but one that is being addressed with a renewed vigor.

Using a similar process of serial working meetings, in 2010 San Diego State University lead a multi-stakeholder, collaborative effort to review regional management and monitoring issues that have arose since the adoption of the first multiple species, multiple habitat conservation programs in the late 1990s.

Based upon shared experience of management and monitoring over the past 15 years, three prevailing themes where identified: (1) how to effectively address different spatial and temporal scales, (2) how to prioritize and coordinate among numerous species and organizational levels, and (3) how to overcome impediments and develop solutions for coordination and implementation of successful monitoring and management programs. A prevailing attitude among the participated was the need for a standardized approach among land managers based upon a scientific framework.

The 2010 effort has two advantages over previous efforts. The first is the pilot monitoring efforts and existing regional collaboration that has resulted during the implementation of the regional conservation plans. The second is a multi-year secure funding source to assist with regional management and monitoring efforts – the *TransNet* Environmental Mitigation Program (EMP).

The EMP was established by the voters in 2004 as part of the 40-years local sale tax extension for regional transportation improvements. A provision of the EMP allows for a portion of funding assisting the regional habitat conservation programs maintain their habitat quality and thus guard against need to listed additional species as endangered under the federal and/or state Endangered Species Act. To this end SANDAG has entered into a Memorandum of Agreement with the federal and state governments to provide four million dollars per year until at least 2018 to assist with regional management and monitoring efforts.

As of January 1, 2012, SANDAG has allocated $19 million dollars toward these efforts. As a result, the San Diego Management and Monitoring Program (www.sdmmp.com) has been established to facilitate communication among land managers, promote best management practices, and help to prioritize regional management and monitoring needs. SDMMP is funded to complete the region’s first regional Management Strategic Plan which will identify regional goals and objectives at the regional and local management scale, identify key stressors, develop a ranking schema to help inform land managers, and address the level and scale of biological monitoring.

In addition, the San Diego State Institute for Ecological Monitoring and Management (http://iemm.sdsu.edu/) has been contracted to develop a standardized approach that incorporates science into local land management plans. An interactive workshop held in November 2011 focused on writing definitive goals and objectives for local management plans. Another workshop will be held in February 2012 on use of conceptual models in the implementation of land management. IEMM has been working with individual preserve managers to build scientific capacity, and will be selecting 4-5 preserve to pilot a standardized management approach.

These two efforts will help address the prevailing theme of the 2010 Dahlem workshop regarding prioritization, scale and standardization. Additional, species and habitat specific monitoring is also being paid for through the *TransNet* EMP and include post-fire monitoring, vegetation mapping and monitoring, California gnatcatcher and cactus wren monitoring, and rare butterfly surveys.

Over twenty years ago, the State's Natural Communities Planning (NCCP) program outlined a bold vision to conserve and manages species at the landscape level, while allowing compatible and appropriate economic activity. It has been over fourteen years since the first regional habitat conservation plan in San Diego, and additional plans have been approved in Southern California and have emerged in the central valley and bay delta region.

The San Diego region is evolving from the conservation of habitat lands, towards the adaptive biological management of these lands. The Dahlem conference described in the preceding report represents a point in time as a reference of the regional needs and a road map for future actions. The *TransNet* EMP coupled with local, state and federal funds can propel the region into the next paradigm of management and monitoring, and hopefully will serve as a model for the emerging NCCPs.

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