FINAL

Management and Monitoring Strategic Plan for Conserved Lands in Western San Diego County: *A Strategic Habitat Conservation Roadmap*

Volume 2: Goals and Objectives

2017

VOLUME 2A: REGIONAL PRESERVE SYSTEM

1.0 OVERVIEW OF THE REGIONAL PRESERVE SYSTEM

The Natural Community Conservation Planning (NCCP) program plans were developed with the goal of ensuring the long-term persistence of viable populations of covered plant and animal species and their natural habitats and of maintaining ecosystem functions (City of San Diego 1998; SANDAG 2003). Biological monitoring was intended to track population trends of covered species and detect changes in habitat quality to determine conditions requiring active management, and to assess how well the conservation strategy was working to maintain natural ecological functions (Ogden 1996; SANDAG 2003).

The San Diego NCCPs have been monitoring and managing biological resources since at least the mid-1990s. However, few long-term monitoring studies have been implemented that can answer the question of how well the entire preserve system is working and whether conservation and management goals are being met. How is the preserve system changing through time in response to threats, such as climate change and wildfires? Now that much of the preserve system is assembled, the next step is to implement a long-term regional preserve system monitoring program to track environmental changes through time, such as changes in abiotic conditions and threats, and relate these to changes in the status of species, vegetation communities, and ecosystem functions to make better informed management decisions.

There are 4 target monitoring groups in the Management and Monitoring Strategic Plan for Conserved Lands in Western San Diego County: *A Strategic Habitat Conservation Roadmap* (or simply "MSP Roadmap" or "MSP"): abiotic, threats, vegetation, and MSP species (see Vol. 1, Sec. 2.4.2). Abiotic monitoring tracks abiotic conditions (e.g., climate, soils, and hydrology) over time and evaluates factors associated with changing conditions. Threats monitoring focuses on determining the types and levels of threats and understanding why they change over time, testing best management practices (BMPs), and evaluating the success of management to reduce threat levels (Vol. 2B). Vegetation monitoring tracks the distribution, composition, structure, and integrity of vegetation communities over time and identifies threats and abiotic factors associated with changes in community attributes (Vol. 2C). Vegetation monitoring also informs development of BMPs and assesses whether management is effective at reducing threats and improving vegetation characteristics. MSP species monitoring concentrates on documenting changes in species distribution and status and how such changes are related to threats, vegetation, and abiotic factors (Vol. 2D). Species monitoring also includes conducting targeted research studies to address critical uncertainties, developing BMPs, and evaluating management effectiveness at reducing threats and enhancing populations.

The regional preserve system monitoring integrates and synthesizes data from these 4 target monitoring groups and from other sources with the goal of evaluating and communicating how well the preserve system is functioning to meet NCCP conservation goals and MSP Roadmap management goals. This assessment is intended to (1) characterize the level of success at meeting conservation goals; (2) describe what has been done to protect, maintain, and improve the preserve system; (3) explain what has been learned from monitoring and managing conserved resources; and (4) to provide indicators of ecosystem health or condition.

The MSP Roadmap focuses on managing for the ecological integrity of vegetation communities and ecosystems (Vol. 1 Sec. 2.4.1 and Sec. 2.4.2), an important component of the regional preserve system goal. Ecological integrity measures the ability of an ecological system to support and maintain species composition, diversity, and functions that are within the range of historical variation or comparable to that of natural pristine habitats in the region (Parrish et al. 2003). A system with high ecological integrity is more resilient to threats and natural disturbance processes and has the ability to return to its original state following disturbance (Parrish et al. 2003; Wurtzebach and Schultz 2016). Evaluating resilience in relation to the historical or current range of variability can allow inference about rates of recovery and the potential for regime shifts (Seidl et al. 2016). Managing to increase resilience is especially important under changing disturbance regimes where there is increased uncertainty and stochasticity of disturbance processes.

Characterizing the condition and health of the preserve system under an increasing array of threats and natural disturbances leads to the primary question: *What is the ecological integrity of the MSPA preserve system, is it changing over time and why?*

Monitoring the ecological integrity of the preserve system requires identifying key attributes to survey that characterize environmental conditions; the type and magnitude of threats and their interactions; and the responses of species, vegetation communities, and ecosystem processes.

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2.0 STUDY DESIGN

2.1 REGIONAL PRESERVE SYSTEM MONITORING APPROACH

Regional preserve system monitoring involves a 2-pronged approach. When addressing ecological integrity, it is important to evaluate processes at multiple scales, including the landscape scale at which larger processes operate (Seidl et al. 2016). The first step is to conduct an office-based assessment of the preserve system using geographic information system (GIS) data layers to develop landscape-scale metrics that characterize environmental conditions across the MSP Roadmap Area (MSPA). This is considered CORE monitoring and can be conducted annually or less frequently if there are no updates to the underlying spatial data. The process involves compiling all GIS-based data layers and predictive models and determining which variables are relevant to characterizing the integrity of the preserve system. Some potential data sources include current and future climate conditions, soil attributes, fire history, nitrogen deposition rates based on predictive models, fragmentation and road impact calculations, artificial night lighting levels, invasive plant distributions, and vegetation community classification based on regional (vegetation class) and preserve level (alliance, association) vegetation mapping.

The second approach is to collect field-based monitoring data that characterize the condition of the preserve system at specific sites and provide detail on threats; environmental conditions; and the status of MSP species, vegetation communities, and ecosystem processes. There is overlap between the different levels of monitoring that can be used to improve efficiencies where feasible. Vegetation monitoring can be designed as part of a larger ecosystem integrity monitoring effort, such that permanent vegetation sampling plots are co-located with monitoring plots where taxonomic groups, ecosystem processes and threats are monitored to assess ecosystem integrity. Specific monitoring questions will be developed for characterizing ecological integrity to determine which covariate and response variables to measure, to prioritize the various variables for monitoring, and to determine the frequency and schedule of monitoring. The long-term permanent vegetation monitoring plots, considered CORE+ monitoring, will be established across the MSPA to encompass the range of variation in east-to-west and north-to-south environmental gradients.

The addition of other components to track the ecological integrity of the system is considered CORE++ monitoring. The additional monitoring components could include monitoring MSPA species, surveying the biodiversity of various taxa, monitoring indicator species selected to represent the response of a suite of species to ecosystem processes, measuring important ecosystem processes, and determining the type and level of anthropogenic threats. These additional components may be monitored using rapid assessments and optimized protocols. Data from these add-on monitoring components can be used to calibrate whether vegetation data are sufficient to characterize ecological integrity for the broader preserve system. Some variables might be measured just once (e.g., soil texture, soil type, topography), others on a regular basis (e.g., vegetation), or continuously (e.g., weather station climate variables).

2.2 SELECTION AND EVALUATION OF METRICS TO CHARACTERIZE THE REGIONAL PRESERVE SYSTEM

An important step in designing a regional preserve system monitoring program is to work with land managers, wildlife agencies, and scientists to review existing GIS-based data sources and monitoring program datasets to select appropriate metrics for evaluating and communicating the status of the preserve system. These monitoring metrics should be based on indicators that are useful for conveying information about the ecological integrity (i.e., composition, structure, and function) of the system over time and across spatial scales (Wurtzebach and Schultz 2016). In selecting monitoring indicators, it is important to use conceptual models or summaries of existing knowledge about key ecological interactions (Parrish et al. 2003; Wurtzebach and Schultz 2016), such as relationships between threats and MSP species, vegetation communities, and ecosystems processes. Using this information, it is possible to select key attributes of the system as monitoring metrics that characterize the regional preserve system and can be tracked over time and across multiple spatial scales (Wurtzebach and Schultz 2016). An Index of Biological Integrity (IBI) can also provide an overall assessment of the ecological integrity of an ecosystem, but can be problematic due to the complexity of terrestrial ecosystems (Wurtzebach and Schultz 2016). An IBI has been developed for coastal sage scrub that performs well in distinguishing integrity classes across a disturbance gradient (Diffendorfer et al. 2003).

A number of different metrics can be used to characterize and communicate how well the preserve system is working. Various monitoring data will be selected, compiled, analyzed, and synthesized to provide simple to complex metrics evaluating the overall state of the preserve as well as success in meeting specific MSP species, vegetation, and threat management goals. The types of metrics selected to characterize the status of the preserve system depend in part on the target audience. Simple metrics can be compiled that are most relevant to the public and decision makers and that provide easily understood descriptors of how the preserve system is doing overall. More complex metrics may be applicable to land managers, scientists, and others involved with making management decisions. These metrics often require greater knowledge of the system to interpret and typically involve analyses of biologically complex datasets to determine whether management objectives are being met, to fully characterize the status and ecology of the monitoring target, and to understand threat and habitat relationships.

Ecological integrity metrics can be used to assess whether is it likely that conservation and management goals will be achieved for long-term persistence of viable populations of MSP species in their natural habitats or the maintenance of ecosystem functions. For example, if measures of ecological integrity for a particular vegetation community are found to be rapidly declining across the MSPA, this could be a warning that it may not be possible to meet the conservation goal of long-term persistence for the vegetation community and potentially for the MSP species dependent on it. However, with directed and appropriate management, ecological integrity metrics can also demonstrate the response of the vegetation community to management and, if successful, an improved likelihood of meeting conservation goals. Ecological integrity metrics provide a simple way to conceptualize more complex ecological processes and explain what has been learned from managing different components of the preserve system. Ecological integrity metrics also provide a way to characterize the overall health or condition of an ecosystem and of the individual components. Summarizing different metrics can provide an indication of the overall status of the preserve system.

Examples of some simple metrics for communicating with the public and decision makers include reserve assembly metrics, such as the total amount of land and number of vegetation communities conserved and lost to development since the

NCCPs were established, with perhaps a comparison of these metrics to the pre-NCCP period. Other simple metrics are more ecologically based and characterize the health of the preserve system. An example includes using remote imagery to map ecological integrity classes over time to determine the number of acres of shrubland that have converted to nonnative grassland across the MSPA. MSP species datasets could be used to assess the status of groups of species, such as coastal sage scrub dependent species, rare plants, highly threatened and vulnerable species, or wide-ranging species. Threat metrics could characterize the magnitude of different threats across the MSPA, including fire risk (e.g., departure from historic median fire return intervals, probability of ignition, number of times burned since 2000), invasive species, constrained linkages, and climate change projections with modeled species responses. Management metrics could describe the investment in and effectiveness of management actions to illustrate efforts taken to protect and improve the preserve system.

Meta-analyses and syntheses of landscape-scale and field-based metrics will be used to characterize different aspects of the preserve system to identify common effects or landscape-scale patterns. These analyses evaluate how well the preserve system is functioning and if conservation and management goals are being achieved. Communicating metrics clearly is important and relies on a format that is accessible and can effectively communicate information to managers and the public. The best metrics for communicating with a more general audience are conceptually simple key indicators that describe the status of the preserve system and important MSP species, vegetation communities, and ecological processes. Score cards are an effective way of communicating with assessment categories based on historic range of variation or comparisons with pristine natural systems (Wurtzebach and Schultz 2016). These thresholds can also be used in management decision making by land managers and to trigger further evaluation of the system, vegetation, or species.

3.0 LANDSCAPE SCALE INDICES MONITORING (CORE)

The office-based evaluation of the preserve system incorporates landscape-scale GIS data layers for the MSPA to characterize current environmental conditions, different types and levels of threats, MSP species distributions, and vegetation community types. Statistical analyses and modeling will be used to create GIS layers that predict current and future conditions across the landscape, such as species habitat suitability models for different scenarios of climate change, climate variability and refugia modeling, cumulative threat vulnerability rankings, fire risk analyses, connectivity constraints, and biodiversity hotspots. Landscape-scale assessments can be done on a periodic basis and are considered CORE level monitoring.

3.1 GIS-DATA LAYERS

Potential GIS data sources for characterizing the regional preserve system include land use maps, climate layers, Digital Elevation Models to describe topography, soil maps, vegetation maps, fire perimeters, burn severity maps, erosion potential maps, satellite imagery, high resolution aerial photos, and LIDAR (Light Detection and Ranging). GIS databases include Conserved Lands, MSP-MOM, SC-MTX, rare plant monitoring spatial data, SANBIOS, CNDDB, and various species monitoring spatial datasets. Table V2A.1-1 provides examples of types of variables that can be calculated and included as metrics to characterize the preserve system or that can be incorporated into more complex analyses to develop synthetic metrics. For example, vegetation maps can be used to calculate the number of different vegetation types in the preserve system and can also be used to calculate variables used in habitat suitability models or connectivity modeling.

3.2 GIS-BASED MODELS

GIS data layers can be used to develop spatially explicit models and conduct complex analyses. These include species habitat suitability models under current and future climate, land use, and fire scenarios; climate change projections; climate variability and refugia analyses; watershed urbanization and water flow models; nitrogen deposition models; carbon sequestration models; connectivity models; and fire risk models.

Table V2A.1-1. Examples of simple landscape-scale metrics that can be calculated with GIS to characterize the regional preserve system.

Type of Data	Landscape-Scale Metric
Climate	Precipitation
	Maximum/minimum air temperature
Connectivity	# Major roads and highways that cross core areas
	# Major roads and highways that cross linkages
	# Patches, average patch size (other calculations of fragmentation/edge)
	# Functional linkages
Conserved Land	# Acres in conservation
	Ratio of developed to conserved acres
	# Preserves, # Preserves with active land management
	# Cores, # linkages
Ecological Integrity	Ecological integrity classification mapped with remote imagery
Fire	Fire history and risk
Human Use	# Preserves open to public
	Predicted average daily use (Colorado State University model)
Hydrology	% of watershed developed
Soils	Soil texture, nitrogen, carbon, phosphorus, soil type, pH, available water capacity
Species	# MSP species, # SL, SO, SS, VF, VG # Significant occurrences, # significant occurrences conserved
	# Significant occurrences actively managed/monitored
Vegetation	#Vegetation types at group level, acres of each

An example of how multiple data layers can be incorporated into a synthetic analysis is a cumulative stressors analysis (Table V2A.1-2) conducted by the San Diego Management and Monitoring Program (SDMMP) that assesses the accumulation of threats to identify areas in the MSPA that are particularly affected by known stressors. In this example, the accumulation of stressors was calculated as an index that measures the relative level of each threat across the MSPA. The threats considered included road density, urban edges/Argentine ants, fire frequency, feral pigs, and invasive plants (see Vol. 2B for more info on threats). For each threat, a raster layer was created where each cell (10 feet by 10 feet) contained a point value (0–4) relating to the level of threat present. More intense stressors were given higher point values. The sum of all the threat point values created a relative scale of cumulative threat level. The raster layers for each threat were summed to produce an overall score of cumulative threats. The higher value numbers indicate a higher threat to habitat. The maximum possible index value was 20.

Table V2A.1-2. Point values used to calculate the cumulative threat index.

Threats	Attribute Points Were Based upon	4	3	2	1	0
Road Density	Feet of road per square mile	>76,000	26,001–76,000	14,001–26,000	2,501–14,000	0–2500
Urban Edge/ants	Percent of preserve 250 meters or less from urban area	76–100	51–75	26–50	1–25	0
Fire Frequency	No. of fires since 1990	>4	3	2	1	0
Feral Pigs	Distance from evidence point	<0.5 mile	0.5–1 mile	1–1.5 mile	1.5–2 mile	>2 miles
Invasive Plants	No. of invasive plants per 1 mile grid	82–1,589	32–81	10–31	2–9	0–1

3.3 REGIONAL ENVIRONMENTAL ABIOTIC MONITORING STATIONS

A network of remote automated weather stations and soil sensors will be established to continuously monitor abiotic conditions across the regional preserve system, particularly climate-related variables that are important to the distribution and status of MSP species and vegetation communities and ecological processes. It is important to characterize climate at a relatively fine scale across the landscape in order to assess how climate and soil variables affect monitoring targets. The network of automated weather stations will be established at preserves and will also include, as feasible, existing weather station networks (e.g., National Oceanic and Atmospheric Administration, San Diego Gas and Electric Company). Soil data loggers can be placed at long-term permanent vegetation monitoring sites. The types of abiotic variables that can be measured at weather stations include ambient temperature (average, minimum, and maximum), precipitation, relative humidity, fog, and wind speed and direction. Soil data loggers can measure soil moisture and temperature. These variables can be monitored throughout the annual cycle and at different scales using continuous data loggers. Data from these stations will be used as covariates in analyses of species distribution and status, and vegetation community composition and structure, and to assess ecological processes.

4.0 SITE-SPECIFIC FIELD-BASED MONITORING

Most of the monitoring conducted in the MSPA is site-based field monitoring as part of MSP species, vegetation communities, and threat management and monitoring objectives. Other monitoring components can be added in as feasible to address questions that are important to regional preserve system integrity monitoring.

4.1 VEGETATION MONITORING (CORE+)

CORE+ monitoring includes long-term vegetation monitoring that typically consists of establishing permanent plots and a rotating panel of plots to expand the spatial sampling area (see Vol. 2C). Types of monitoring variables include community composition and structure, integrity, and abiotic and threat assessments. Vegetation communities with objectives for this type of monitoring in 2017–2021 include coastal sage scrub, chaparral, grassland, oak woodland, and riparian forest and scrub. Plant monitoring metrics may include species richness, percent cover, plant height, density, population size, seedling recruitment, and mortality. The types of abiotic variables measured can include climate data from automated weather stations and soil sensors, soil attributes from site-specific sampling, and topography variables generated from GIS. Threats are assessed at the site including fire, altered hydrology, disease, herbicides, human use, invasive plants, invasive animals, pests, loss of ecological integrity, and urban development. Threats can also be characterized based on GIS layers such as altered fire regime, climate change, loss of connectivity, and urban development. For chaparral, coastal sage scrub, and grassland vegetation monitoring, ecological integrity metrics include describing the level of disturbance from nonnative plants and are interpreted in relation to fire and drought (see Vol. 2C).

4.2 TAXA MONITORING (CORE++)

CORE ++ includes monitoring components to evaluate the ecological integrity of the regional preserve system and typically builds upon vegetation monitoring at permanent plots. As feasible, it can include monitoring of the status and habitat and threats of MSP species (SL, SO, SS and VF species). Additional monitoring components can include community level monitoring of arthropods, amphibians, reptiles, birds, and small mammals (Table V2A.1-3). The U.S. Geological Survey (USGS) is developing rapid assessment protocols to monitor threats and various taxonomic groups and preparing community level monitoring optimized protocols for greater efficiency. Other types of monitoring include assessing food webs (e.g., arthropod food resources for MSP bird species), animal movement (digital camera stations), pollinator services, carbon cycling, soil microbes, and biotic interactions (Table V2A.1-4). Threat monitoring can include components identified above for vegetation monitoring. A multi-taxon IBI can also be developed based on rapid assessments and optimized sampling of different taxonomic groups and added to the vegetation monitoring component to sample ecological integrity across the MSPA. Diffendorfer et al. (2007) conducted a study of 5 plant and animal taxomic groups in coastal sage scrub vegetation and found that an IBI could be developed to characterize ecological integrity across a disturbance gradient of invasive nonnative grasses. They found that the IBI performed better than traditional community metrics and that no single taxon was a good indicator of the responses of the other taxa to the disturbance gradient. Responses to disturbance were varied and complex among the different taxonomic groups and there was large variation at multiple scales in abiotic and biogic conditions across the study area. The IBI was able to address this variability and characterize the ecological integrity of sites with 1 measure, which could be decomposed into individual components to understand how the different taxa responded to the disturbance gradient.

Table V2A.1-3. Examples of components for CORE++ monitoring.

Variable Measured	Metric
Vegetation	Species composition, % cover, structure, mortality, and recruitment
Birds	Species and taxa detected (inventory list through time)*
Mammals	Species and taxa detected (inventory list through time)*
Herps	Species and taxa detected (inventory list through time)*
Arthropods	Species and taxa detected (inventory list through time)*

*May use citizen scientists for some types of monitoring. USGS is developing and testing optimized animal protocols.

Table V2A.1-4. Examples of metrics that can be measured across the preserve system.

Variable Measured	Field-Based Metric
Invasiveness	# Invasive plant species detected
	# Invasive upland animal species detected (rapid assessment protocol)
	# Invasive aquatic animal species detected (rapid assessment protocol)
	Ratio of native to nonnative species
	% preserves with Argentine ants present beyond 250-meter edge
	IBI – Index of Biological Integrity
	% Cover of nonnative annual grasses and forbs
	Thatch cover
Pests & Disease	Presence of pests and disease pathogens
Hydrology	# Days of surface water flow vs no water flow Maximum/minimum surface water temp
Human disturbance	% cover trash
	% cover illegal trails

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5.0 GOALS AND OBJECTIVES FOR THE REGIONAL PRESERVE SYSTEM

The goal for the regional preserve system is to maintain, enhance, and restore native ecosystems within a network of connected Conserved Lands across the MSPA to support vegetation communities with high ecological integrity, biodiversity, and natural ecological processes and that provide for self-sustaining MSP species populations resilient to environmental stochasticity, and catastrophic disturbances and threats, and that will likely persist over the long term (>100 years). This goal does not represent a substantial new management and monitoring effort; rather, it incorporates management and monitoring goals and strategies for individual MSP species, vegetation communities, and threats into a broader overall regional preserve system goal.

During the 2017–2021 planning cycle, there is an objective to analyze and synthesize existing GIS-based datasets characterizing conditions across the MSPA, including the distribution and magnitude of threats; vegetation communities; ecological integrity of chaparral, coastal sage scrub, and grasslands; abiotic monitoring elements; and MSP species. From these analyses, clear, easily understood monitoring metrics will be developed to communicate with the public and policy makers the status of the preserve system. A State of the Preserve Report will be prepared in 2017 and the metrics will be posted on the MSP Portal. These analyses will be repeated in 2020 and expanded to include more complex monitoring datasets arising from abiotic, threat, vegetation, and MSP species monitoring objectives. A more detailed State of the Preserve Report will be prepared in 2020 with monitoring metrics displayed on the MSP web portal. The general goals, objectives, and actions for the regional preserve system are listed on the MSP Portal under the Regional Preserve System summary page (https://portal.sdmmp.com/tracker.php?Target=preserve+system&MonMgtObjType=&ActionStatus=&ManagementUnit=&ObjectiveType=&Year=&Preserve=&Short=Long&submit=Submit).

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