9.0 LOSS OF ECOLOGICAL INTEGRITY

9.1 OVERVIEW

Ecological integrity provides a framework aimed at conserving native biodiversity by using natural or historic variation as a standard for evaluation and for promoting resilience, or the capacity of a system to retain functions and structure following disturbance (Wurtzebach and Schultz 2016). Ecological integrity is defined by Parrish et al. (2003) as follows:

> *…the ability of an ecological system to support and maintain a community of organisms that has species composition, diversity and functional organization comparable to those of natural habitats within a region.*

Ecological processes, including natural disturbance regimes, are important in providing the structure and functions upon which species in the ecosystem or landscape depend (Wurtzebach and Schultz 2016). An ecological system with high integrity is one where different aspects of the system, such as composition, structure, and function, are within the natural range of variation and when impacted by natural or human-caused disturbance can recover to its previous state (Parrish et al. 2003; Wurtzebach and Schultz 2016). Resilience is a measure of the capacity of a system to respond to disturbance and recover to its former state or to remain within the range of variation for that system by maintaining critical ecosystem processes (Seidl et al. 2016). Systems that maintain their native species and natural processes are thought to be more resilient to natural disturbances and anthropogenic threats over time (Parrish et al. 2003). Systems with low ecological integrity are not as resilient and may be shifted into new system domains when disturbed.

Measuring the ecological integrity of a specific system at a specific location requires comparing aspects of the ecosystem with pristine and undisturbed reference sites or by comparing it with measures in the historic range of variation for that system (Wurtzebach and Schultz 2016). These comparisons give an indication of how degraded the system is at a particular site and define its ecological integrity. In many cases, the historic range of variation is unknown and the comparison is among contemporary systems, carefully selected to best reflect what are hypothesized to be natural, high integrity systems.

The concept of ecological integrity is used by land managers to communicate and evaluate how well conservation and management goals are being met (Barbour 2000; Parrish et al. 2003). It is particularly applicable to habitat-based biodiversity conservation strategies (Wurtzebach and Schultz 2016). 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. They also provide a way to characterize the overall health or condition of an ecosystem and of the individual components.

9.2 LOSS OF ECOLOGICAL INTEGRITY IN THE MSPA

Loss of ecological integrity in the MSPA includes disturbance-induced changes beyond the bounds of historic or natural variation in ecosystem components of composition, structure, and function. Ecosystem composition is the variety of living things within the ecosystem and is defined by attributes such as species richness, evenness, and diversity (Wurtzebach and Schultz 2016). Ecosystem structure includes physical features of the ecosystem like vegetation cover, height, and density or larger landscape-scale features such as patch size and configuration (Wurtzebach and Schultz 2016). There is growing concern that the composition and structure of coastal sage scrub, chaparral, oak woodlands, and riparian forests in some areas of the MSPA are being altered by a suite of interacting threats. An altered fire regime and nitrogen deposition are facilitating the invasion of nonnative grasses into coastal sage scrub and chaparral vegetation communities leading to declines in native shrubs and forbs and simplification of the vegetation community (Vol. 2B, Sec. 1 and 7; Vol. 2C, Sec. 1). Oak woodlands and riparian forests are experiencing large-scale tree die-offs from the combined effects of drought, invasive pests, and novel fungal pathogens (Vol. 2C, Sec. 4 and 7). Loss of ecological integrity in these vegetation communities affects other species inhabiting them, potentially leading to declines in biodiversity as well as certain MSP species.

Important ecological functions or natural processes operating within the historic or natural range of variation are critical for maintaining ecological integrity. Examples of these processes within the MSPA include the hydrologic cycle, nutrient cycling, predator-prey relationships, pollination services, primary productivity, food webs, and natural disturbance regimes such as fire and floods.

9.3 RESULTS OF LOSS OF INTEGRITY STUDIES IN THE MSPA

Within the MSPA, a multi-taxon Index of Biological Integrity (IBI) was developed for coastal sage scrub and there have been a number of studies showing examples of loss in ecological integrity.

Diffendorfer et al. (2007) conducted a study of 5 plant and animal taxomic groups in coastal sage scrub vegetation and found that a multi-taxon 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 biotic 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.

Several examples show how the ecological integrity and resilience of ecosystems in some areas of the MSPA are declining. A number of studies in the MSPA and broader southern California region have documented poor post-fire recovery of coastal sage scrub vegetation subjected to an altered fire regime of too frequent fire leading to conversion to a more simplified grassland ecosystem (Vol. 2B, Sec. 1). Conversion to grassland is also affecting post-fire reptile, bird, and mammal communities in the MSPA, often simplifying composition and structure (Vol. 2B, Sec. 1). Fire has directly impacted other species, such as Hermes copper, with lack of recovery attributed partially to lack of nearby populations to recolonize burned habitat. Habitat loss and fragmentation are associated with a lower species richness and higher proportion of generalist species in native bee communities in the MSPA (Hung and Holway 2014). Habitat loss and fragmentation are also associated with reduced connectivity of species such as coastal cactus wren and mountain lions, leading to low genetic diversity and isolated populations vulnerable to extinction (Vol. 2D).

9.4 MANAGEMENT AND MONITORING APPROACH

The primary management focus for the MSP Roadmap is to reduce threats to maintain or enhance high levels of ecological integrity and resilience at prioritized and interconnected species occurrences, vegetation communities, and ecosystems (see Vol. 1, Sec. 2). Managing for high ecological integrity and then monitoring species and system responses at managed and unmanaged sites can lead to a greater understanding of the species or system's capacity to persist under changing environmental conditions and with appropriate management. Ensuring there are multiple interconnected occurrences with high ecological integrity reduces the vulnerability of a species to local extinction or extirpation from the MSPA.

CORE ++ monitoring includes components to evaluate the ecological integrity of the regional preserve system and typically builds upon vegetation monitoring (CORE+) at permanent plots (Vol. 2A). Ecological integrity may be mapped for vegetation communities across the MSPA using remote imagery to characterize integrity classes based on vegetation composition, structure, and plant mortality. These ecological integrity classification maps will be evaluated and validated so they can be used in developing a sampling design for vegetation monitoring and for tracking changes in integrity across the MSPA over time. Vegetation monitoring also includes collecting field-based data on ecological integrity at sampling sites. This will involve selecting and evaluating aspects of the vegetation community to monitor that are representative of the integrity of the system. For coastal sage scrub, this could include using a field-based multi-taxon IBI (Diffendorfer et al. 2007) or using simpler measures of invasive grass cover, shrub cover, and density (see Vol. 2C Sec. 1).

Ecological integrity may also be incorporated into monitoring the status, habitat, and threats of MSP species (SL, SO, SS, and VF species). This will involve identifying variables to measure that reflect habitat integrity for each species. Additional ecological integrity add-on monitoring components can include community level surveys of arthropods, amphibians, reptiles, birds, and small mammals to measure biodiversity of vegetation communities. USGS is developing rapid assessment protocols to monitor various taxonomic groups and is also preparing community-level optimized monitoring protocols that provide greater efficiency. Other types of ecological integrity monitoring include assessing ecosystem processes, such as food webs (e.g., arthropod food resources for MSP bird species); animal movement (e.g., digital camera stations); pollinator services; carbon cycling; soil microbes; and biotic interactions. 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). 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.

Information obtained through monitoring loss of integrity for species, vegetation communities, and ecosystem processes will be important in identifying and prioritizing management objectives and actions. Results from loss of ecological integrity monitoring will be used to formulate recommendations to be incorporated into management plans for species, vegetation communities, and ecosystem processes.

9.4.1 General Approach Objectives

Below is a summary of the general monitoring objectives for loss of ecological integrity in the 2017–2021 planning cycle. There are no general ecological integrity management objectives in the current planning cycle. For the most up-to-date objectives and actions, refer to the MSP Portal Loss of Ecological Integrity summary page: (https://portal.sdmmp.com/view_threat.php?threatid=TID_20161230_1459).

The overall goal for loss of ecological integrity in the MSPA is to protect, maintain, enhance, and restore natural communities and important ecosystem processes to maintain high levels of ecological integrity in the regional preserve system over the long term (>100 years).

There are 3 general approach objectives for loss of ecological integrity in the 2017–2021 planning cycle. The first objective is to prepare a monitoring plan for riparian and oak woodland bird communities to assess community composition and diversity and the distribution and abundance of individual species across the MSPA that are under threat from tree die-offs due to invasive nonnative pests, fungal pathogens, and drought (see Vol. 2B, Sec. 6; Vol. 2C, Sec. 4 and 7). The second objective is to implement riparian and oak woodland bird community monitoring across the MSPA. The third objective is to prepare a monitoring plan to survey pollinator communities and assess pollinator functions in coastal sage scrub, chaparral, and forblands across the MSPA. Implementation of the pollinator monitoring plan is delayed until the 2022–2026 planning cycle.

9.4.2 Species-Specific and Vegetation Approach Objectives

Descriptions of loss of ecological integrity management approaches, rationale, goals, objectives, and actions for at-risk MSP species and vegetation communities are presented in the corresponding species, threats, and vegetation sections.

Species-specific and vegetation objectives that address ecological integrity are often combined with other threat objectives to reduce threat impacts and improve resilience of populations to enhance continued persistence. These include collecting data on ecological integrity as part of species and vegetation monitoring and developing an ecological integrity map for coastal sage scrub, chaparral, and grassland across the MSPA using remote imagery. Management objectives for MSP species and vegetation communities focus on management to improve habitat quality. Loss of ecological integrity monitoring objectives and actions are presented in the corresponding species sections. Links to species-specific and vegetation objectives that apply to loss of ecological integrity are provided in Table V2B.9-1. Use the MSP Portal for the most updated list of species and vegetation communities with Loss of Ecological Integrity objectives.

9.5 LOSS OF ECOLOGICAL INTEGRITY REFERENCES

Barbour, M. T., W. F. Swietlik, S. K. Jackson, D. L. Courtemanch, S. P. Davies, and C. O. Yoder. 2000. *Measuring the Attainment of Biological Integrity in the USA: A Critical Element of Ecological Integrity*. Springer.

Diffendorfer, J. E., G. M. Fleming, J. M. Duggan, R. E. Chapman, M. E. Rahn, M. J. Mitrovich, and R. N. Fisher. 2007. Developing a Terrestrial, Multi-taxon Indices of Biological Integrity: An Example from Coastal Sage Scrub. *Biological Conservation* 140:130–141.

Hung, K-L., and D. A. Holway. 2014. Connectivity Project Summary of At Risk Resource: Native Bees (Hymenoptera: Anthophila).

Parrish, J. D., D. P. Braun, and R. S. Unnasch. 2003. Are We Conserving What We Say We Are? Measuring Ecological Integrity within Protected Areas. *BioScience* 53:851–860.

Seidl, R., T. S. Apies, D. L. Peterson, S. L. Stephens, and J. A. Hicke. 2016. Searching for Resilience: Addressing the Impacts of Changing Disturbance Regimes on Forest Ecosystem Services. *Journal of Applied Ecology* 53:120–129.

Wurtzebach, Z., and C. Schultz. 2016. Measuring Ecological Integrity: History, Practical Applications, and Research Opportunities. *BioScience* 66:446–457.

Table V2B.9-1. MSP plant and animal species, and vegetation communities with specific Loss of Ecological Integrity management and monitoring objectives.

Scientific Name	Common Name	Management Category	Summary Page Link
Plants			
Quercus engelmannii	Engelmann Oak	VF	https://portal.sdmmp.com/view_species.php?taxaid=19329
Invertebrates			
Euphydryas editha quino	Quino checkerspot butterfly	SL	https://portal.sdmmp.com/view_species.php?taxaid=779299
Vegetation Communities			
Chaparral			https://portal.sdmmp.com/view_species.php?taxaid=SDMMP_vegcom_3
Coastal Sage Scrub			https://portal.sdmmp.com/view_species.php?taxaid=SDMMP_vegcom_1
Grassland			https://portal.sdmmp.com/view_species.php?taxaid=SDMMP_vegcom_2
Oak Woodland			https://portal.sdmmp.com/view_species.php?taxaid=SDMMP_vegcom_10
Riparian Forest & Scrub			https://portal.sdmmp.com/view_species.php?taxaid=SDMMP_vegcom_7