Out-Of-Kind Mitigation Guidance for Coastal California: Phase 1 Report Appendix

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Appendix: Mitigation Working Group Materials

Introduction to the Appendix

The following appendix contains materials generated by working groups during our two-day in-person meeting in May 2023. These materials were developed as part of the discussions and collaborative efforts around five initially identified components critical to our mitigation framework. After evaluating these components, the working groups focused their efforts on three core areas: ecological structure, ecological function, and ecosystem services.

Sub-groups were then formed to explore each of these core components in more depth, specifically within the context of out-of-kind mitigation. In the report, we have combined two of these components—ecological structure and ecological function—into a single core component, while maintaining ecosystem services as a distinct focus.

The materials provided in the appendix offer supporting details, context, and descriptions for each core component, which were generated by working group members. These resources serve as an extension of the main report, enriching the discussions and recommendations with additional insights and perspectives.

1.1.1 Component: Ecosystem Services

1.1.1.1 Definition

Ecosystem Services are the benefits provided to people which are derived from the structure and/or function of an ecosystem. They are diverse and include provisioning, regulating, cultural and supporting services. Often taken for granted, an ecosystem service is often identified once it has been removed or threatened.

While many components articulate basic aspects of the system in question, Ecosystem Services are defined by their utility to humans. It is therefore important to consider the beneficiaries of the services (i.e., who potentially benefits from the occurrence of those services) in their designation. Because the potential beneficiaries vary from place to place, ecosystem services vary from place to place. In addition to the direct beneficiaries, ecosystems typically have an "existence value" which is the value to society due to the presence of the ecosystem.

Ecosystem services refer to the inherent ecological characteristics, functions, or processes that play a pivotal role in supporting and enhancing human wellbeing. These services are either provided directly or indirectly by functioning ecosystems and encompass a wide range of benefits that people obtain from the natural environment. These benefits can be both tangible and intangible, and they significantly contribute to the sustenance and prosperity of human societies. Ecosystem services include but are not limited to the provisioning of essential resources such as food, water, and raw materials, the regulation of climate, water purification, pollination of crops, flood control, and disease regulation.

Additionally, they also offer cultural and recreational advantages, nurturing emotional and spiritual connections with nature. The recognition and understanding of ecosystem services have become important in environmental and socio-economic discussions. As human activities continue to exert pressure on the natural world, comprehending and valuing these services become critical for sustainable development and wise resource management.

https://www.sciencedirect.com/science/article/abs/pii/S2212041617304060
https://www.usgs.gov/centers/geosciences-and-environmental-change-science-center/science/ecosystem-services-assessment#overview

1.1.1.2 Example/Representative Components

4 different types of ecosystem services (regulating, provisioning, cultural, and supporting)

Include the benefits of these types of ecosystem services

- **Provisioning** is a vital ecosystem service with many goods and resources that benefit humanity. These tangible benefits are essential in sustaining society and supporting various economic activities because many provisions are sold in the market. Below are some key components of provisioning ecosystem services:

- *Food:* Ecosystems are the primary source of food production, supplying various crops, livestock, and fisheries. Traditional and modern agriculture heavily relies on the fertile soils, water availability, and climatic conditions provided by ecosystems to cultivate crops and raise livestock.
- *Raw Materials:* Ecosystems are abundant reservoirs of raw materials used in various industries. Forests, for instance, provide timber and non-timber products like latex, resins, and gums, which are fundamental to the construction, manufacturing, and pharmaceutical sectors.
- *Fresh Water:* Ecosystems are critical in regulating the water cycle, ensuring a continuous fresh water supply. Rivers, lakes, and aquifers sourced from natural ecosystems fulfill communities' water needs for drinking, irrigation, and industrial purposes.
- *Medicinal Resources:* Many medicines are derived from plant and animal species found in ecosystems. Indigenous communities, for centuries, have relied on traditional knowledge of medicinal plants, and modern pharmaceutical industries continue to explore natural sources for potential drug development.
- *Wood and Fiber:* Forest trees provide wood for construction, furniture, and paper products. Additionally, plant fibers, such as cotton and jute, sourced from ecosystems, are used in the textile industry.
- *Fuel:* Biomass from forests and other ecosystems is a fuel source for cooking, heating, and electricity generation, especially in rural and resource-limited regions.

These provisioning services are essential for human well-being, livelihoods, and economic prosperity.

- Foley, J. A., DeFries, R., Asner, G. P., Barford, C., Bonan, G., Carpenter, S. R., ... & Helkowski, J. H. (2005). Global consequences of land use. Science, 309(5734), 570-574.
- Millennium Ecosystem Assessment. (2005). *Ecosystems and Human Well-being: Synthesis*. Island Press.
- Daily, G. C. (Ed.). (1997). Nature's services: societal dependence on natural ecosystems. Island Press.
- Food and Agriculture Organization of the United Nations. (2023) Provisioning Services. www.fao.org/ecosystem-services-biodiversity/background/provisioning-services/en/.

- **Regulating** is an ecosystem service that involves the natural processes that help maintain and balance the environment, ensuring the continuous provision of various ecosystem services. These regulatory services play an essential role in safeguarding the health and stability of ecosystems and contribute significantly to human well-being. Here are some examples of regulating ecosystem services:
  - *Air Quality:* Ecosystems, particularly forests, play a pivotal role in regulating air quality by absorbing pollutants and releasing oxygen through photosynthesis. Trees and vegetation act as natural filters, mitigating air pollution and enhancing the overall air quality in their surroundings.
  - *Carbon Sequestration and Storage:* Forests, wetlands, and other ecosystems serve as carbon sinks, sequestering and storing carbon dioxide from the atmosphere.

This process helps mitigate climate change by reducing the concentration of greenhouse gasses in the atmosphere.

- *Wastewater Treatment:* Wetlands and aquatic ecosystems have a natural ability to treat and purify wastewater. Through a combination of physical, chemical, and biological processes, these ecosystems remove pollutants and nutrients from the water, making it safe for human consumption or release back into water bodies.
- *Erosion Prevention:* Vegetation, such as grasslands and forests, prevents soil erosion. Plant roots bind the soil, reducing erosion caused by wind and water and maintaining soil fertility for agriculture and other land uses.
- *Pollination:* Ecosystems, particularly pollinator habitats like bee colonies, butterflies, and birds, facilitate the pollination of plants. This process is essential for reproducing many flowering plants, including crops, ensuring the continuation of food production.
- *Biological Control:* Natural predators and beneficial organisms in ecosystems help control pest populations, reducing the need for chemical pesticides in agriculture. This ecological balance promotes sustainable and resilient agricultural practices.
- *Regulation of Water Flow:* Wetlands and forests act as natural buffers against flooding by absorbing excess water during heavy rainfall and slowly releasing it, thus regulating water flow in river systems and reducing the risk of flood events.

These regulating ecosystem services contribute to the overall stability and resilience of ecosystems, which, in turn, support human societies and their economies.

- Daily, G. C. (Ed.). (1997). Nature's services: societal dependence on natural ecosystems. Island Press.
- Millennium Ecosystem Assessment. (2005). *Ecosystems and Human Well-being: Synthesis*. Island Press.
- Costanza, R., d'Arge, R., de Groot, R., Farber, S., Grasso, M., Hannon, B., ... & Paruelo, J. (1997). The value of the world's ecosystem services and natural capital. Nature, 387(6630), 253-260.
- Pimentel, D., Zuniga, R., & Morrison, D. (2005). Update on the environmental and economic costs associated with alien-invasive species in the United States. Ecological Economics, 52(3), 273-288.

- **Supporting** (providing living space and diversity of plants and animals)
  - Habitat

- **Cultural** (benefits people receive that are non-material)
  - Recreation, mental health, physical health, tourism, art inspiration, spiritual experience

https://www.fao.org/ecosystem-services-biodiversity/background/cultural-services/en/

Ecosystem services are traditionally presented in dollar values.
https://nap.nationalacademies.org/read/11139/chapter/6#98

1.1.1.3 Utility (how might we use this; how might we calculate equivalency for this)

1.1.1.4 Relevance/Importance

1.1.1.5 Research Needs/Hurdles

1.1.1.6 Example/Representative Metrics

Examples:

- Groundwater recharge
  - What is this?
  - How is it valued?
  - What are some example values we see in CA?
  - Natural groundwater recharge transpires when precipitation descends upon the Earth's surface, permeates through the soil, and travels through pore spaces until it reaches the water table. Furthermore, recharge can arise through surface-water leakage from rivers, streams, lakes, and wetlands. Another form of recharge involves replenishing groundwater artificially by injecting water directly into wells. This technique is typically used for deep aquifers.
- https://groundwaterexchange.org/groundwater-recharge/ , https://www.usgs.gov/mission-areas/water-resources/science/artificial-groundwater-recharge
- Water quality (pollution sequestration, filtration)
- Community benefit (recreational opportunities) – identify community that benefits
- Carbon fixation
- Education
- Natural hazard minimization/reduction
- Food provisioning (fisheries)
  - Food provisioning is a provisioning ecosystem service where people extract goods for consumption from the environment. This includes many types of fisheries, including shellfish to top predators. Food provisioning focuses on commercial level fishing, not recreational fishing. Commercial fisheries are valued through market methods, traditionally market price. In this method, researchers use the cost per pound for a fish, and multiply that by the catch rate of the fish for that area. The result provides researchers with an estimate of the total fisheries value for a specific region. In California, Miller et al. (2017) spatially quantified the value of marine fisheries through 1935-2005 through spatial catch data and commercial price data from multiple sources. They found that 88% of the fisheries caught were finfish, which constituted the largest ecosystem service value for the marine fisheries. Fisheries provisioning service values are used for increasing our understanding for stock assessment, and spatial planning of fisheries management.
  - https://cdnsciencepub.com/doi/full/10.1139/cjfas-2016-0228?casa_token=4SRE5P6gL80AAAAA%3A06HOAoP58_vUzT_EbffEbJLWrZUEVD4Cop38Hliu3GkGsHcu4DeIIBGiiUHx6DZmkT0pszt526WhhZM

Supporting Service - Habitat

1. What is the habitat service?
2. How is it measured?
   a. Monetary Example
   b. Non-monetary Example
3. What methods are used to measure it?
4. Who are the beneficiaries?

Supporting Service - Fisheries/Food Production
1. What is this service?
2. How is it measured?
   a. Monetary Example
   b. Non-monetary Example
3. What methods are used to measure it?
4. Who are the beneficiaries?

Regulating Service - Erosion Protection

What is this service?
The ecosystem service of erosion protection is a critical natural mechanism that safeguards landscapes, coasts, and habitats from the erosive forces of wind, water, and other environmental factors. Erosion, the gradual wearing away of soil and land surfaces, can have profound ecological, economic, and social implications. Erosion protection, offered by healthy and intact ecosystems, plays a pivotal role in maintaining the integrity of landscapes and ensuring the resilience of communities against the challenges posed by natural processes and human activities.

Erosion as a Threat:
Erosion is a natural phenomenon accelerated by factors like deforestation, urbanization, agriculture, and climate change. Uncontrolled erosion can lead to the loss of fertile topsoil, degradation of water quality, and destruction of habitats. Moreover, eroded sediments can clog waterways, leading to increased flood risks and damaging downstream infrastructure. Coastal erosion, driven by waves, tides, and storm surges, threatens properties and habitats, exacerbating the vulnerability of coastal communities to rising sea levels and climate-related events.

Ecosystems as Shields:
Healthy ecosystems provide a range of protective services that mitigate the impacts of erosion. Vegetation, such as forests, grasslands, and wetlands, plays a crucial role in stabilizing soils. Plant roots bind the soil together, preventing it from being easily washed or blown away. Forests, for instance, act as natural barriers against water erosion, reducing the speed and force of runoff. In coastal regions, mangroves and saltmarshes act as natural buffers, absorbing wave energy and protecting shorelines from erosion.

Sediment Control:
Ecosystems also regulate sediment movement. Wetlands and marshes trap sediment carried by water, preventing it from being transported downstream. By intercepting sediments, these

ecosystems help maintain water quality, prevent siltation in water bodies, and contribute to the health of aquatic habitats.

Climate Change Adaptation:
The erosion protection service takes on even greater significance in the context of climate change. Rising sea levels and increased storm intensity amplify erosion risks along coastlines. Ecosystems like coral reefs, dunes, and coastal vegetation offer critical defense against storm surges, reducing the impact on human settlements and infrastructure. Additionally, maintaining healthy landscapes contributes to carbon sequestration, helping mitigate climate change and its associated impacts.

Economic and Societal Benefits:
Erosion protection translates into substantial economic benefits. Healthy ecosystems reduce the costs associated with erosion control infrastructure, such as seawalls and retaining structures. Furthermore, the preservation of productive soils sustains agriculture and supports food security. In coastal areas, maintained shorelines support tourism, a crucial economic sector for many regions.

Challenges and Conservation:
Despite the significant role of ecosystems in erosion protection, they face numerous threats. Deforestation, urban sprawl, and land degradation compromise the ability of ecosystems to offer effective defense. To harness the erosion protection service, conservation efforts must prioritize the restoration and preservation of critical habitats. Afforestation, reforestation, and the restoration of wetlands are key strategies to enhance the protective capacity of ecosystems.

In conclusion, the ecosystem service of erosion protection is an invaluable natural defense mechanism that shields landscapes, habitats, and communities from the destructive forces of erosion. By recognizing and prioritizing the role of ecosystems in erosion control, we can foster sustainable land management practices that ensure the resilience of ecosystems, support local livelihoods, and mitigate the impacts of erosion, ultimately contributing to the long-term well-being of both nature and society.

How is it measured?

Monetary Example
Ecosystems that provide erosion protection services can lead to substantial monetary savings by reducing the need for costly engineering solutions. For instance, coastal wetlands like mangroves and saltmarshes act as natural barriers against erosion and storm surges. The cost to construct and maintain artificial seawalls or breakwaters is often significantly higher than conserving or restoring these natural ecosystems. By relying on the natural erosion protection services offered by wetlands, governments and communities can save on construction and maintenance expenses while achieving effective coastal defense.

Non-Monetary Example
The protection of coastal communities from erosion's impacts, like property damage and habitat loss, represents a significant non-monetary benefit of the erosion protection service. Coastal

vegetation such as dunes and mangroves dampen the force of waves and reduce the risk of storm surges reaching inland. The presence of these natural buffers can prevent the displacement of communities and the destruction of homes, preserving people's way of life and reducing the need for costly post-disaster recovery efforts. The resulting peace of mind and societal stability are non-monetary gains that underscore the importance of erosion protection.

What methods are used to measure it?

Measuring the ecosystem service of erosion protection involves a range of interdisciplinary approaches that evaluate the capacity of ecosystems to mitigate the impacts of erosion and protect landscapes from degradation. These methods assess both the physical processes of erosion control and the economic and societal benefits derived from these services.

1. Hydrological and Geotechnical Assessments:
Scientific studies employ hydrological and geotechnical techniques to analyze how ecosystems influence erosion processes. Field measurements and monitoring help quantify parameters such as runoff, sediment deposition, and soil stability. By comparing erosion rates in areas with and without intact ecosystems, researchers can estimate the degree of erosion protection offered by these habitats.

2. Sediment Trapping and Analysis:
Ecosystems, such as wetlands and forests, often act as sediment traps, capturing eroded material and preventing it from reaching water bodies. Researchers collect and analyze sediment samples to determine the extent of sediment retention. These analyses provide insights into the erosion protection capabilities of different ecosystems.

3. Modeling and Remote Sensing:
Advanced technologies like geographic information systems (GIS) and remote sensing are used to model erosion patterns and assess the protective capacity of ecosystems. These tools generate maps that show areas prone to erosion and identify zones where ecosystems play a crucial role in safeguarding against erosion. These models inform land-use planning and conservation strategies.

4. Erosion Control Infrastructure Costs:
A common method to measure the erosion protection service's value is to compare the costs of implementing and maintaining artificial erosion control structures with the costs associated with conserving or restoring natural ecosystems. This approach quantifies the monetary savings achieved by relying on the ecosystem's natural erosion control capabilities.

5. Property Value Assessments:
Erosion protection often has a direct impact on property values, particularly in coastal areas. Researchers analyze real estate market data to determine how properties located near intact ecosystems that provide erosion protection command higher prices compared to those without such natural defenses. This method indirectly quantifies the nonmonetary benefits of erosion protection.

6. Coastal and Landscape Morphology Studies:
Ecosystems play a role in shaping coastal and landscape morphology. Researchers examine changes in landforms, sediment distribution, and erosion rates in areas with different ecosystem covers. These studies help understand how ecosystems contribute to long-term landscape stability.

7. Erosion Hazard Mapping:
Assessing erosion risk and producing hazard maps is an effective way to visualize the areas most vulnerable to erosion. Overlaying such maps with information about the presence of protective ecosystems allows for the identification of regions where these services are crucial.

8. Socioeconomic Surveys:
To understand the societal benefits of erosion protection, socioeconomic surveys can be conducted to gather data on how communities perceive and value these services. Surveys may ask about residents' awareness of erosion risks, their preferences for natural protection, and their willingness to pay for the preservation or restoration of ecosystems that provide erosion control.

In summary, measuring the ecosystem service of erosion protection requires a blend of scientific, economic, and societal approaches. By combining these methods, researchers can comprehensively evaluate the physical and intangible benefits that ecosystems offer in mitigating erosion's impacts. These measurements inform policymakers, land managers, and communities, enabling them to make informed decisions that sustain the protective capabilities of ecosystems and secure both ecological resilience and human well-being.

Who are the beneficiaries?
The ecosystem service of erosion protection extends its benefits to a wide array of beneficiaries, ranging from local communities and industries to entire ecosystems and the global environment. This vital service, provided by intact and healthy ecosystems, plays a crucial role in safeguarding landscapes, habitats, and human well-being from the destructive forces of erosion, thereby creating a ripple effect of positive impacts across various dimensions.

1. Coastal Communities:
Coastal regions are particularly vulnerable to erosion caused by waves, tides, and storm surges. Coastal communities benefit immensely from the protective capabilities of ecosystems such as dunes, mangroves, and saltmarshes. These natural barriers mitigate erosion and reduce the risk of damage to infrastructure, properties, and livelihoods. By safeguarding against coastal erosion, these ecosystems help maintain the resilience of communities in the face of rising sea levels and climate-related events.

2. Agriculture and Food Security:
Erosion can lead to the loss of fertile topsoil, compromising agricultural productivity and food security. The beneficiaries here include farmers who rely on healthy soils for crop growth and livestock grazing. Ecosystems that prevent soil erosion, such as grasslands and forests, ensure that arable land remains productive and can continue to support global food production.

3. Infrastructure and Property Owners:

Intact ecosystems play a significant role in protecting infrastructure, including roads, bridges, and buildings, from erosion-induced damage. By reducing sediment runoff and stabilizing soils, these ecosystems help preserve the integrity of vital infrastructure and prevent costly repairs and disruptions.

4. Biodiversity and Ecosystem Health:
Erosion can degrade habitats and impact biodiversity by altering ecosystems and reducing the availability of resources for species. Erosion protection services provided by intact ecosystems maintain the health and integrity of habitats, supporting a diverse range of flora and fauna. Biodiversity, in turn, contributes to ecosystem stability, resilience, and the provision of other ecosystem services.

5. Fisheries and Aquatic Ecosystems:
Erosion can introduce sediments and pollutants into water bodies, harming aquatic habitats and compromising fisheries. By preventing sediment runoff, ecosystems like wetlands and forests contribute to the maintenance of water quality and the preservation of aquatic ecosystems. This has positive implications for fish populations, biodiversity, and the livelihoods of those dependent on fisheries.

6. Tourism and Recreation Industry:
Coastal and natural landscapes are popular destinations for tourism and recreation. The preservation of scenic coastal areas and recreational spaces ensures continued attractiveness to tourists seeking serene and unspoiled environments. Erosion protection contributes to sustainable tourism and supports the livelihoods of those in the tourism industry.

7. Climate Change Mitigation and Adaptation:
Erosion protection services offered by ecosystems play a role in climate change mitigation and adaptation. Coastal ecosystems, for example, sequester carbon dioxide and help reduce greenhouse gas concentrations in the atmosphere. Additionally, preserved coastal habitats can act as buffers against the impacts of sea-level rise and extreme weather events.

8. Future Generations and Global Environment:
Preserving ecosystems that provide erosion protection benefits future generations by maintaining healthy landscapes and habitats. Additionally, the global environment benefits from the role these ecosystems play in mitigating climate change and maintaining ecological balance, contributing to the health of the planet as a whole.

In summary, the beneficiaries of the ecosystem service of erosion protection are diverse and interconnected. The protection of landscapes, habitats, and human well-being from the impacts of erosion is a shared responsibility that transcends geographical and sectoral boundaries. By recognizing and prioritizing the value of intact ecosystems, we can ensure that the benefits of erosion protection extend to present and future generations, fostering sustainability, resilience, and harmonious coexistence with nature.

Cultural Service - Recreation
What is this service?

Ecosystem services are the invaluable contributions that nature provides to human well-being and the functioning of societies. Among these services, the often underappreciated yet profoundly significant service of recreation plays a pivotal role in enhancing our quality of life and fostering a harmonious connection with the natural world. Recreation as an ecosystem service encompasses a range of activities and experiences that individuals and communities engage in for leisure, relaxation, and enjoyment within natural environments. From hiking through lush forests to basking on sandy shores, from birdwatching in wetlands to angling in pristine lakes, the opportunities for recreation offered by ecosystems are diverse and abundant.

Recreation not only offers respite from the demands of modern life but also nurtures physical, mental, and emotional well-being. Engaging with nature through recreational activities has been linked to stress reduction, improved mood, increased physical fitness, and enhanced cognitive function. This service not only satisfies our innate desire for leisure but also contributes to holistic health, making it an essential aspect of human life.

One of the most remarkable aspects of the recreational ecosystem service is its inclusivity. It transcends age, ability, and background, providing accessible and inclusive avenues for people to experience the natural world. Whether it's a family enjoying a picnic in a park, an individual going for a morning jog along a scenic trail, or a group embarking on a nature photography expedition, these experiences promote social cohesion, foster connections among diverse groups, and cultivate a shared appreciation for the environment.

Recreation holds particular significance in urban settings where green spaces and natural areas offer respite from the urban hustle and bustle. Parks, urban forests, and waterfronts provide essential breathing spaces that counteract the concrete jungle's stresses. These recreational spaces promote a healthier urban lifestyle, offering opportunities for physical activity, social interaction, and cultural enrichment. As cities continue to grow, the provision of accessible recreational spaces becomes a key aspect of urban planning for improving residents' overall well-being.

The economic implications of the recreation ecosystem service are substantial as well. Nature-based tourism, which often revolves around recreational activities, constitutes a significant portion of many economies. From ecotourism destinations attracting travelers to experience pristine ecosystems to recreational fishing charters providing angling experiences, these activities generate revenue, create jobs, and stimulate local economies. Moreover, the recreational value of natural areas can enhance property values and support real estate markets.

Preserving and managing natural areas to provide recreational opportunities necessitates careful planning and sustainable practices. Balancing the increasing demand for recreational spaces with conservation efforts is a complex task that requires cooperation among government agencies, conservation organizations, and local communities. Sustainable trail systems, waste management, and visitor education programs are essential components of effective recreational management that ensure these activities do not degrade ecosystems.

In a rapidly urbanizing world where technological advances often draw us away from the natural world, the ecosystem service of recreation serves as a powerful reminder of our intrinsic connection to the environment. By partaking in recreational activities, we reaffirm our role as stewards of the Earth, advocating for the conservation and preservation of ecosystems for current and future generations. As communities continue to recognize the multifaceted benefits of this service, integrating recreational spaces and activities into conservation strategies becomes not only a matter of leisure but a crucial step toward fostering sustainable societies that thrive in harmony with the natural world.

How is it measured?

Monetary Example

Many natural areas attract tourists who seek recreational activities such as hiking, wildlife watching, and camping. Tourists often spend money on accommodations, transportation, guided tours, and recreational equipment. For instance, a national park might offer guided nature hikes for a fee, generating revenue that can be used for park maintenance, conservation efforts, and community development. The monetary value derived from entrance fees, tour charges, and related expenses contributes directly to local economies and supports jobs within the tourism industry.

Non-Monetary Example

Engaging in recreational activities in natural environments can yield substantial non-monetary benefits. Consider a family that regularly spends weekends hiking in a nearby forest. While they may not be spending money on entrance fees or rentals, they experience improved physical health through exercise, better air quality, and exposure to natural sunlight. Additionally, these outings contribute to their mental well-being by reducing stress, enhancing mood, and fostering a sense of connection with nature. While difficult to quantify in monetary terms, the positive impact on the family's health and overall quality of life is immeasurable.

What methods are used to measure it?

Measuring the ecosystem service of recreation involves a multidimensional approach that seeks to quantify the social, economic, and environmental benefits derived from engaging in leisure activities within natural environments. Understanding the methods used to measure this service is essential for assessing its significance, guiding management strategies, and making informed decisions that sustain both recreational opportunities and the ecosystems that support them.

1. Visitor Surveys and Interviews:

Gathering direct feedback from visitors through surveys and interviews is a common method to assess the recreational value of natural areas. These surveys inquire about visitors' preferences, behaviors, and willingness to pay for recreational activities. By analyzing responses, researchers can estimate the value people place on different aspects of the experience, such as access, scenery, and solitude. This approach provides insights into the nonmonetary benefits of recreation, such as improved mental well-being and connection to nature.

2. Revealed Preference Methods:

These methods infer recreational values based on people's actual behavior, such as their spending patterns related to recreational activities. Travel cost analysis, for example, involves assessing the expenses individuals incur to reach and enjoy a particular recreational site. By examining travel expenses and visitation rates, researchers can estimate the value visitors attach to the experience and the site's recreational amenities.

3. Contingent Valuation Surveys:
Contingent valuation involves presenting individuals with hypothetical scenarios and asking them to express their willingness to pay for certain recreational experiences. These scenarios might involve questions about preserving a particular natural area or improving recreational facilities. By analyzing respondents' willingness to pay, researchers can assign a monetary value to the recreational services provided by the ecosystem.

4. Market Valuation:
Some recreational services have direct market values, such as entrance fees for parks, charges for guided tours, or rentals of recreational equipment like kayaks or bicycles. These direct market transactions provide clear monetary values for specific recreational experiences. Market valuation methods focus on actual transactions and expenditures, making them relatively straightforward to quantify.

5. Health and Well-being Indicators:
While challenging to monetize, the health and well-being benefits of recreation can be assessed using various indicators. Health studies might measure changes in stress levels, physical fitness, and mental health before and after engaging in outdoor recreational activities. These indicators offer insights into the nonmonetary value of improved well-being and its associated positive impacts on individuals' lives.

6. Remote Sensing and Geographic Information Systems (GIS):
Geospatial technologies are increasingly used to map and analyze the spatial distribution of recreational activities and preferences. GIS allows researchers to identify popular recreation areas, analyze patterns of use, and understand how different factors, such as accessibility and scenery, influence people's choices. These insights inform land-use planning and management decisions.

7. Qualitative Approaches:
Qualitative methods, such as focus groups and ethnographic studies, delve into the nuanced aspects of recreational experiences. These approaches explore the emotional, cultural, and social dimensions of recreation, providing a deeper understanding of the intangible values associated with spending time in natural settings.

In conclusion, measuring the ecosystem service of recreation requires a combination of quantitative and qualitative methods that capture both the monetary and nonmonetary benefits. These approaches offer insights into how people value and engage with nature for leisure, enabling decision-makers to prioritize conservation efforts, design sustainable recreational infrastructure, and cultivate a deeper appreciation for the multifaceted benefits of ecosystems.

Who are the beneficiaries?

The beneficiaries of the ecosystem service of recreation are diverse and encompass a wide spectrum of individuals, communities, and society as a whole. This service transcends age, background, and socioeconomic status, delivering a multitude of physical, mental, social, and cultural advantages to those who engage in leisure activities within natural environments.

1. Individuals and Families:
At the core of the beneficiaries are individuals and families seeking respite, rejuvenation, and enjoyment. Recreation in natural settings offers a sanctuary from the stresses of daily life, providing opportunities to unwind, reflect, and recharge. Hiking through forests, picnicking in parks, or simply taking a leisurely stroll along a shoreline can offer a temporary escape from the hustle and bustle of urban environments. Families, in particular, benefit from quality time spent together, fostering bonding and cherished memories.

2. Physical and Mental Health Enthusiasts:
Recreation in natural environments contributes significantly to physical and mental well-being. Outdoor activities such as jogging, cycling, and swimming promote physical fitness, leading to improved cardiovascular health, enhanced stamina, and weight management. Exposure to natural sunlight also aids in the synthesis of Vitamin D, essential for bone health and overall immune function. Furthermore, engagement with nature has been linked to reduced stress levels, alleviation of anxiety and depression, and enhanced cognitive function. These benefits resonate with individuals seeking holistic health improvements.

3. Urban Dwellers:
For those residing in densely populated urban areas, natural areas offer an oasis of tranquility and a direct connection to the natural world. Urban parks, waterfronts, and green spaces provide opportunities for residents to escape the concrete jungle, indulge in outdoor activities, and rejuvenate amidst greenery. This respite contributes to improved mental well-being and counters the adverse effects of urban stressors.

4. Tourism and Hospitality Industries:
The tourism and hospitality sectors also reap substantial benefits from the ecosystem service of recreation. Nature-based tourism draws travelers seeking outdoor adventures, scenic beauty, and unique experiences. From ecotourism destinations to recreational fishing charters, these activities stimulate local economies by generating revenue through accommodation bookings, tour packages, and dining expenditures.

5. Local Communities:
Communities residing near natural areas experience a range of advantages. Access to recreational spaces promotes social cohesion, fostering connections among community members. Well-designed parks and recreational facilities enhance the quality of life, making neighborhoods more attractive places to live. Additionally, recreational amenities can drive property values, further benefiting local residents.

6. Cultural and Spiritual Seekers:
For some, engaging in recreation within natural landscapes holds cultural and spiritual significance. Indigenous communities, for example, may view certain areas as sacred, engaging

in traditional practices and ceremonies that maintain their cultural heritage. People seeking solitude, reflection, or connection to their spiritual beliefs also find solace in natural settings.

7. Children and Future Generations:
Introducing children to the wonders of nature through recreational experiences fosters an early appreciation for the environment. Such exposure can spark curiosity, promote environmental consciousness, and inspire the next generation to become stewards of the Earth.

In essence, the ecosystem service of recreation bestows its benefits far and wide, touching the lives of individuals seeking leisure, health, cultural enrichment, and a harmonious connection with the natural world. The beneficiaries encompass not only those directly engaging in recreational activities but also communities, industries, and societies at large, making this service a cornerstone of sustainable well-being and a bridge between humanity and nature.

1.1.2 Component: Ecological Functioning

1.1.2.1 Definition

According to the 2008 "Mitigation Rule" (33 C.F.R. Parts 325 and 332), functions are defined as the physical, chemical, and biological processes that occur in ecosystems (U.S. Army Corps of Engineers & Environmental Protection Agency). While humans may ascribe value or consider functions to provide services to them, the functions or processes occur in these ecosystems regardless.

1.1.2.2 Example/Representative Components

There is a commonality in many of the variables targeted to evaluate ecosystem health, though they may be categorized differently between institutions (Shafer and Yozzo 1998, Fennessy et al. 2004). We will refer to ecosystem functions using the three categories defined by the U.S. Army Corps of Engineers and the Environmental Protection Agency (EPA): 1) Biogeochemistry, 2) Hydrology, and 3) Habitat Support (US Army Corps of Engineers and Environmental Protection Agency 2008).

> Biogeochemistry includes carbon fixation, nutrient cycling (such as nitrification/denitrification), sediment detention and filtration, and contaminant transformation.
>
> Hydrology includes groundwater recharge, sediment transport, water source(s), hydro-dynamics, and water storage.
>
> Habitat support includes wildlife connectivity, biodiversity/species support, resistance to invasive species, and productivity.

1.1.2.3 Utility (how might we use this; how might we calculate equivalency for this)

To achieve a realistic level of equivalency, functions can be considered a form of currency in a sense that can be used to evaluate the pace, extent, or nature of ecosystem processes - productivity rates, seasonality, direction and volumes of water flows, the cycling of constituents, measures of biodiversity, etc.

Other functions like connectivity might be interpreted as a degree and over larger landscape scales, such as that of gene flow for a species of interest or the number of species reliant on a corridor for movement across the landscape, including the extent the corridor may reach across the landscape. Aquatic resource functioning also is influenced by and often dependent on adjacent upland areas - during high flows, for example, some wildlife species require accessible higher ground/upland areas to take refuge until flows recede. Adjacent upland areas also offer important future habitat opportunities as landward transgression across the tidal plane occurs as sea levels rise.

Restoring affected ecosystems to the same levels of the original functions is usually not realistic, however, regardless of the methods used. Even on-site and in-kind mitigation rarely achieves the same levels of lost functions, and offsite and out-of-kind mitigation presents additional variables that limit what can be fully replaced or gained at a mitigation site. This can be seen in a project in San Diego Bay to establish new nesting sites for the light-footed clapper (*Rallus longirostris levipes*) rail along damaged intertidal marshes. This species requires tall cordgrass (*Spartina foliosa*; the majority of stems more than 60 cm and a substantial portion more than 90 cm tall), but the soil at the established sites was coarse-grained (mainly sand) and did not have enough organic matter and nitrogen to produce sufficiently tall cordgrass for light-footed clapper rails.

Another option is to provide habitat of similar or higher relative level of functional capacity, condition, or "quality" as what is being lost, even if the impact and mitigation habitat types differ (e.g., replacing poorly functioning riverine habitat with poorly, moderately, or highly functional salt marsh habitat). Rather than focusing on replacing specific functions or capacity to perform at particular levels of those exact functions, this type of approach focuses on considering the relative "quality" of habitat within its class and ensuring that level of quality is replaced, regardless of habitat type. Essentially, for example, a moderately functioning riverine wetland would be evaluated, with respect to function or capacity to perform functions only, the same as a moderately functioning salt marsh wetland, even though the habitat types are different and they perform different functions to different degrees. Both are, overall, moderately functioning examples of their respective habitat types. Whether one "should" be chosen to mitigate for the other would be based on other factors, such as the Ecosystem Services they each provide, etc.

1.1.2.4 Relevance/Importance

Functions are the processes as they exist in the ecosystem and whether biotic or abiotic, provide a common currency for relating and comparing across different systems. For example, nutrient cycling occurs in saltmarsh as well as riparian wetlands and though the structures of these habitats take different forms, the ecological function offers a means for translating the relative contribution across them. Where in-kind mitigation options may not be available, establishing the relative contribution of each may afford a quantitative basis for guiding the proportion of out-of-kind mitigation necessary in order to adequately compensate for the loss of the impacted resource.

1.1.2.5 Research Needs/Hurdles

The main hurdle for assessing function is that we rarely observe or measure functions in the field, which would entail experimentation. Instead, we observe indicators or biotic or abiotic features or attributes that are correlated with underlying processes occurring at the assessed site. Furthermore, the relationship between an indicator or set of indicators and an underlying function is often not well understood; in fact, in many cases, it is not linear. Also, in out-of-kind mitigation cases, the functions assessed at a mitigation site are often different in type and degree relative to functions at the impact site. For example, floodplain storage at an impact site with a low-order/headwater stream at the top of a watershed would typically be less than a mitigation site located in a high-order stream with well-developed floodplains closer to the outlet of the watershed. As an example of starkly different marine habitat types, tidal surge attenuation and vascular plant communities occurring at a salt marsh impact site would not occur in open tidal water areas. Both habitats, of course, perform functions, but the functions each provides and the degree of performance differ. From strictly a functional assessment perspective, a highly functioning tidal water can be considered equivalent to a highly functioning salt marsh site. However, there could be ecosystem service, landscape, temporal/historical, or other considerations that support evaluating them differently in determining, for example, appropriate and adequate mitigation to address marine impacts.

1.1.2.6 Example/Representative Metrics

Review examples of potential metrics and submetrics to use from HGM Guidebooks and CRAM Field Books (perennial estuarine, bar-built estuarine (i.e., tidal inlet is closed some part of the year), and riverine wetland)) and other relevant function and condition assessment tools and methods. CRAM Field Books define and describe various metrics and submetrics that are used to calculate 4 attribute scores in assessing the overall aquatic habitat condition of the assessment area (AA) (in a simplistic sense - condition is an aggregation, "roll-up", or overall snapshot of ecosystem functions, or overall health or integrity):

- Buffer and Landscape Context (aquatic area abundance, percentage of assessment area with buffer, average buffer width, and buffer condition);
- Hydrology (water source, hydroperiod, and hydrologic connectivity);
- Physical Structure (structure patch richness, topographic complexity); and
- Biotic Structure (number of layers in the plant community, number of co-dominant species in the plant community, percent invasion of the plant community, horizontal interspersion, and vertical biotic structure).

In reviewing the CRAM Field Books for perennial estuarine, bar-built estuarine, and riverine wetlands, specific metrics and submetrics to consider include:

- Aquatic Area Abundance (percentage of the transect passing through aquatic features of any kind), with Stream Corridor Continuity, Adjacent Aquatic Area, and Marine Connectivity being submetrics to assess (within 500 meters of the wetland) at Bar-built Estuarine sites.
- Buffer (adjoining the AA in a natural or semi-natural state)), with Percent AA with Buffer, Average Buffer Width, and Buffer Condition as submetrics to assess.
- Water Source (looking at dry season freshwater sources)
- Hydroperiod (frequency and duration of inundation or saturation by tidal prism)
- Hydrologic Connectivity (ability for water to move laterally over the AA surface)
- Structural Patch Richness (number of different types of physical surfaces or features, such as wrack, sediment mounds, burrows, algal mats, and large woody debris)
- Topographic Complexity (variety of macro- and micro-elevations, interspersion of patch types)
- Plant Community (vascular macrophytes), with Number of Plant Layers Present (≥5% of AA), Number of Co-dominant Species (≥10% of relative area of plant cover in each plant layer in the AA), and Percent Invasion (percent of the total number of co-dominant species that are invasive) as submetrics.
- Horizontal Interspersion (variety and interspersion of distinct plant zones; amount of edge between the zones)
- Vertical Biotic Structure (interspersion and complexity of plant layers/canopy density of living vegetation, entrained litter, and detritus)

CRAM Field Books also include “Stressor Checklists” useful in identifying factors that might negatively affect habitat condition and particular functions contributing to that condition. These checklists can be informative in developing effective restoration actions.

In reviewing the HGM Guidebooks for tidal fringe wetlands/waters, none currently exists for the South Pacific region, which includes much of California. However, the *National Guidebook for the Application of HGM Assessment to Tidal Fringe Wetlands* (Shafer and Yozzo 1998), the *Regional Guidebook for applying the HGM Approach to Assessing Wetland Functions of Northwest Gulf of Mexico Tidal Fringe Wetlands* (Shafer et al. 2002), which encompasses the coast of Texas/Galveston Bay, and the *Regional HGM Guidebook for Applying the HGM Approach to Assessing Functions of Tidal Fringe Wetlands Along and Mississippi and Alabama Gulf Coast* (Shafer et al. 2007), include functions and variables to consider. The National HGM Guidebook includes the following 8 functions, as well as several variables, or ecosystem or landscape characteristics (similar to metrics in CRAM) contributing to functions, evaluated to assess the *capacity* of tidal fringe wetlands to perform these characteristic functions:

- 3 Hydrogeomorphic Functions - Tidal Surge Attenuation; Sediment Deposition; Tidal Nutrient and Organic Carbon Exchange.
- 5 Habitat Functions - Maintenance of Characteristic Plant Community Composition and Structure; Resident Nekton (fish and macrocrustaceans) Utilization; Non-resident Nekton Utilization; Nekton Prey Pool; and Wildlife Habitat Utilization.

The Texas coast Regional HGM Guidebook includes the following 9 functions (very similar to the National HGM Guidebook):

- 3 Hydrogeomorphic Functions - Shoreline Stabilization; Sediment Deposition; Nutrient and Organic Carbon Exchange.
- 6 Habitat Functions - Maintain Characteristic Plant Community Composition; Plant Biomass Production; Resident Nekton Utilization; Non-resident Nekton Utilization; Maintain Invertebrate Prey Pool; and Provide Wildlife Habitat.

There are 14 variables that contribute to the 9 assessed characteristic functions in the Texas coast Regional HGM Guidebook, including:

- Shoreline Slope (V_{SLOPE}) (more distance (>50 m) from the shoreline to deep water (>2 m MLW) and less slope increase shoreline stabilization potential))
- Average Marsh Width (V_{WIDTH}) (more expansive marshes are more effective at dissipating wave energy)
- Exposure (V_{EXPOSE}) (estimates shoreline erosion potential due to wind-generated wave energy; landscape position and geomorphology are key factors)
- Soil Texture (V_{SOIL}) (more clay-textured soils are less prone to erosion)
- Surface Roughness (V_{ROUGH}) (vegetation increases roughness, which reduces wave energy, promotes accretion, and stabilizes the shoreline)

The Functional Capacity Index (FCI) equation used to assess the Shoreline Stabilization function is calculated as the arithmetic mean of the variable index scores of these 5 variables (all variables are scaled/scored from 0, or lack of that variable or characteristic contributing to function, to 1, or highest sustainable capacity of that variable; FCIs also range from 0, or lack of capacity to perform the function, to 1, or highest sustainable capacity to perform that function). Interdisciplinary Assessment Teams collect and analyze data to identify and scale variables and develop FCI models (simple equations). These data are collected from reference wetlands/waters, encompassing the range of variation for the class and region (referred to as the regional subclass) in light of natural processes, disturbance, and cultural alteration; and the "best in subclass" or "least altered" are referred to as reference standard wetlands/waters (receive FCIs = 1.0).

- Hydrologic Regime (V_{HYDRO}) (assessing if there are restrictions to tidal water exchange)

The FCI equation used to assess the Sediment Deposition function is the geometric mean of the variable index scores of 2 variables (V_{ROUGH}, V_{HYDRO}).

- Vegetative Structure (V_{VEGSTR}) (uses a weighted height and percent cover index to assess vegetative/macrophyte structure complexity)

The FCI equation used to assess the Nutrient and Organic Carbon Exchange function is the geometric mean of the variable index scores of 2 variables (V_{HYDRO}, V_{VEGSTR}).

- Aquatic Edge (V_{EDGE}) (the amount of marsh/water interface or edge; uses GIS to determine an edge to area ratio)
- Nekton Habitat Complexity (V_{NHC}) (assessing the number of possible habitat types at a site relative to the regional subclass - such as high, mid, low marsh, subtidal or intertidal

aquatic features, ponds or depressions, algal mats, coarse woody debris, etc.; focus is fish and macrocrustaceans)

The FCI equation used to assess the Resident Nekton Utilization function is calculated as follows:

$= (V_{EDGE} + 2xV_{HYDRO} + 0.5xV_{NHC})/3.5$

- Opportunity for Marsh Access (V_{OMA}) (calculating the percentage of edge that is tidally connected)

The FCI equation used to assess the Non-resident Nekton Utilization function is calculated as follows:

$= [((V_{EDGE} + 2xV_{HYDRO} + 0.5xV_{NHC})/3.5) \text{ x } V_{OMA}]^{1/2}$

- Total Percent Vegetation Cover (V_{COVER}) (relative proportion of the site that is covered by emergent macrophytic vegetation)

The FCI equation used to assess the Maintain Invertebrate Prey Pool function is calculated as the arithmetic mean of 3 variables (V_{HYDRO}, V_{EDGE}, V_{COVER}).

- Total Effective Patch Size (V_{SIZE}) (larger patch sizes and connectivity with other larger habitat patches increase wildlife habitat support; landscape-scale metric)
- Wildlife Habitat Complexity (V_{WHC}) (more habitat types/heterogeneity increases diversity of wildlife species using the site)
- Total Percent Vegetative Cover (V_{COVER}) <u>or</u> Percent Cover by Typical Species ($V_{TYPICAL}$) (reduced vegetative cover or atypical plant species can adversely affect wildlife species or forage quality; the lower variable score is used in the FCI calculation)

The FCI equation used to assess the Provide Wildlife Habitat function is calculated as follows:

$= [2xV_{SIZE} + V_{WHC} + (\text{Minimum } (V_{TYPICAL} \underline{\text{ or }} V_{COVER}))]/4$

The FCI equation used to assess the Maintain Characteristic Plant Community Composition function is the <u>minimum</u> score between V_{COVER} and $V_{TYPICAL}$. This means degradation of either variable controls or sets the FCI limit for this particular function.

The FCI used to assess the Plant Biomass Production function is simply V_{VEGSTR}.

The Mississippi and Alabama Gulf Coast Regional HGM Guidebook is similar to the Texas coastal Regional HGM Guidebook, but there are differences. The former defines and evaluates 5 additional variables:

- Mean Height of Tallest Herbaceous Vegetation Strata (V_{HEIGHT}) (shorter herbaceous vegetation can be an indicator of degradation (e.g., clapper rails have vegetation height requirements/preferences));

- Percent Cover by Woody Plant Species (V_{WOODY}) (tidal marshes in this region lack woody vegetation, so having woody vegetation present is an indicator of alteration and degradation);
- Percentage Cover by Invasive or Exotic Species (V_{EXOTIC}) (invasive or exotic species are an indicator of tidal marsh degradation);
- Wetland Plant Indicator Status (V_{WIS}) (having dominant drier plant species, FACU or UPL, can be an indicator of tidal marsh degradation); and
- Adjacent Land Use ($V_{LANDUSE}$) (pollutant loading from anthropogenic runoff from adjacent land, if developed, can be an indicator of tidal marsh degradation).

While there are similarities in the functions in both Regional HGM Guidebooks, the differences in variables result in differences in the FCI models or equations, and there are only 5 functions assessed and FCIs used to calculate the *capacity* of tidal wetlands in the Mississippi and Alabama Gulf Coast region to perform these characteristic functions:

- Wave Energy Attenuation, FCI = $[(3xV_{WIDTH} + V_{COVER}/4) \text{ x } V_{EXPOSE}]^{1/2}$
- Biogeochemical Cycling, FCI = $(V_{HYDRO} \text{ x } V_{COVER} \text{ x } V_{LANDUSE})^{1/3}$
- Nekton Utilization, FCI = $(V_{EDGE} + V_{HYDRO} + V_{NHD}/3)$
- Provide Habitat for Tidal Marsh-Dependent Wildlife, FCI = $\{V_{SIZE} \text{ x } [(V_{HEIGHT} + V_{COVER})/2] \text{ x } [(V_{EDGE} + V_{WHD})/2]\}^{1/3}$
- Maintain Characteristic Plant Community Structure and Composition, FCI = [Minimum (V_{COVER} or V_{EXOTIC} or V_{WIS} or V_{WOODY})]

While condition and functional assessment outputs/numbers can be compared for impact and proposed mitigation sites to determine if the anticipated gains could offset losses, there are many assumptions built into these assessment methods, so these are best considered gross quantitative comparisons. Some agencies, such as the Corps, also use qualitative comparisons in some cases (see the SPD Mitigation Ratio Checklist). The qualitative comparison approach recognizes that a quantitative assessment method is not available for particular habitats or locations or that there are substantial concerns about the validity of a quantitative comparison. In such cases, one may compare qualitatively the functions lost at the impact site and the functions that could be gained at the proposed mitigation site. The relative degree of losses or gains can be entered for each evaluated function (using high, medium, low or some other means of recognizing the relative degree of loss or gain), and those can be assessed for all the functions evaluated (or those considered to be particularly important or controlling for that habitat) to assess qualitatively whether the proposed mitigation would offset the impacts (all or those determined to be of primary concern).

Area of Production Foregone (APF) approach to address coastal/open water impacts.

1.1.3 Component: Ecological Structure

1.1.3.1 Definition

Structural components or structural aspects of an ecosystem include the biotic (living) and abiotic (physical) features of that ecosystem.

1.1.3.2 Example/Representative Components

Key structural components discussed as particularly important metrics were trophic complexity, habitat composition, and biodiversity. Research needs are identified below each bullet point.

1. Complexity
   a. Trophic complexity/foodwebs
      i. Inherently connected to function of trophic support and productivity
      ii. Broken down into trophic groups
   b. Habitat complexity
      i. The role of anthropogenic structures in providing habitat complexity is an interesting aspect to consider in the discussion because they provide non-natural function and could be removed as mitigation.
2. Habitat composition at a landscape scale is needed to assist with regional, county or state-wide scale. In the discussion of out-of-kind mitigation, the regional or county-wide scale seems most appropriate. This might start with a description of what habitats are present in a given area, and a goal setting process could be to determine the expected relative percentage goals of a habitat for an area. For example, a guiding principle of Southern CA Wetland Recovery Project states "actions that influence the distribution of wetland archetypes consider the historic, current, and possible future extent, diversity and relative proportion of wetland types within the region."
   a. Another need might be for a habitat classification system that creates groups of coastal habitats that are based on processes and functions rather than habitat types. An archetype is a group of ecosystems that are similar in terms of form, function, and processes. It currently exists for wetlands in southern California in the Southern California Wetland WRP Regional Strategy (2018). For wetlands, the physical conditions used to develop the archetype classifications included catchment properties (levels of water and sediment inputs), wetland area, proportion of subtidal and intertidal area, inlet dimension and condition, and tidal volume.
3. Biodiversity
   a. A key need for additional research is regarding weighted biodiversity indices and metrics in the habitats under consideration. These indices would need to be scaled to be relative to the habitat type (e.g. salt marsh versus eelgrass) and in regional context (e.g. urbanization, climate). In addition, biodiversity can be done at many levels including species (most common) but additional levels should be considered including functional groups.
   b. It also seems important to evaluate the issue of how native versus overall biodiversity (including non-native species) should be evaluated as a goal. Some opinions advocate for provision of native biodiversity as a functional goal or as one in a suite of multiple benefits.
   c. Finally, there is the question of baseline data both in time and in location. Datasets in some regions might be limited without appropriate comparison datasets (e.g. undisturbed Baja marshes are not a good reference).

1.1.3.3 Utility (how might we use this; how might we calculate equivalency for this)

These structural aspects are typically used as metrics of habitat quality or metrics on which to evaluate restoration success (e.g. performance standards). Assessment of structural components is required on both the impact evaluation and restoration sides of the mitigation process. A key need for the effective application and evaluation of mitigation projects (regardless of the type of mitigation) is the development of crosswalks between these structural aspects/metrics and ecosystem functions and services. Ideally this might be conducted for rocky reef habitat, kelp, vegetated salt marsh, oyster beds, intertidal rocky shores, unvegetated mudflats, sandy beach, and coastal dunes.

1.1.3.4 Relevance/Importance

1.1.3.5 Research Needs/Hurdles

1.1.3.6 Example/Representative Metrics

Table 1 provides examples of "traditionally" measured structural components of an eelgrass/seagrass bed and crosswalks those to functions/services based on literature review. Such a list could be generated for habitat type to be considered for mitigation.

Table 1. Example structure-to-function crosswalk for eelgrass (McCune et al. 2020). A matrix illustrating the links of the SAV indicators (vertical axis) to prioritized ecological functions (horizontal axis) for an idealized SAV ecological function monitoring program. The color and the text at the intersections describe the strength of the linkage between indicator and the function as determined by the Technical Advisory Committee, with empty cells indicating no anticipated linkage. Green = a high strength relationship, yellow = medium strength, and red = low strength.

	Substrate stabilization	Carbon Seqestration	Primary Production	Secondary Production	Improving Water Quality	Nekton Habitat	Waterfowl Habitat
* Above ground biomass		Medium	High	High	Medium		
Above ground Carbon and Nitrogen content			Medium	Medium			
* Below ground biomass	Medium	Medium	Medium	Medium			
Below ground Carbon and Nitrogen content			Low				
* Patch area	High	Medium					High
* Area to perimeter ratio						Medium	
* Percent cover					Low	High	
* Shoot density	High		High	High	High	High	
* Leaves per shoot			High	High			
Flowering shoot density			High				
* Shoot height	Medium			High	High	High	High
* Leaf area	Medium		High		High	High	
* Epiphyte biomass			High	High			
Redox potential discontinuity (RPD) depth		High					
Infauna diversity				Medium		Medium	
Infauna biomass				High			
Epifauna diversity				Medium		Medium	
Epifauna biomass				High			
Contaminant content of blades					Medium		

1.1.4 Additional Concerns: Landscape Context

1.1.4.1 Definition

Landscape context is an integrated measure of the quality of biotic and abiotic factors, structures, and processes surrounding a site, and the degree to which they affect the continued existence of the site (NatureServe). It also needs to consider a site's history and potential legacy issues that may affect its path forward (e.g., residual contaminants or fill).

1.1.4.2 Example/Representative Components

Components of this factor include:

a. landscape structure and extent surrounding the site, including genetic connectivity;
b. development/maturity of the surrounding landscape context;
c. ecological processes in the surrounding landscape context;
d. species composition and biological structure of the surrounding landscape context;
e. abiotic physical/chemical factors in the surrounding landscape context

Examples of landscape context include:

- Rarity/historic loss
- Connectivity/isolatedness
- Ecotones
- Proximity to disturbance/urbanization
- Current and near future migration potential

1.1.4.3 Utility (how might we use this; how might we calculate equivalency for this)

To use landscape context in an equivalency analysis to determine the amount of out-of-kind mitigation needed for an impact by quantifying the landscape context of the impacted area and the proposed mitigation area, an integrated measure would need to be developed that could be applied to the impact and mitigation sites. This measure would mainly be determined by location in the landscape rather than activities conducted on the site. Although there might be some opportunities to increase a landscape context score by activities adjacent to a site (like enhancing the quality of the surrounding landscape), for the most part, the score would be determined by the choice of the mitigation site.

Landscape context can also be used to evaluate how an impact or mitigation project affects the distribution of habitat elements, i.e., the mosaic of the landscape.

1.1.4.4 Relevance/Importance

Landscapes are complex phenomena involving the size, shape, and spatial integration of different landscape units and the spatial relationships between those aspects. Of particular interest in the context of mitigation is the land use zone of both the focal area and the surrounding units.

Past activities have already changed the spatial configuration of landscape composition, often creating less contiguous, heterogeneous, and/or connected units across the coastal zone, in effect creating virtual islands in space. These often have more dramatic/distinct edges with minimal ecotones relative to historic conditions.

1.1.4.5 Research Needs/Hurdles

1.1.4.6 Example/Representative Metrics

Source: https://help.natureserve.org/biotics/content/record_management/Element_Occurrence/EO_Landscape_Context.htm#:~:text=An%20integrated%20measure%20of%20the,continued%20existence%20of%20the%20occurrence.

1.1.5 Additional Concerns: Spatial & Temporal Variation

1.1.5.1 Definition

Temporal trajectory represents the rate and magnitude of changes in structure, function or services over time. It includes three main elements relevant to mitigation equivalency: historical condition, restoration timing, and future change or potential for future change.

The USACE definition read "We have added a definition of temporal loss which clarifies that temporal loss is the time lag between the loss of aquatic resource functions caused by the permitted impacts and the replacement of aquatic resource functions at the compensatory mitigation site. Temporal loss is one factor that must be considered in determining compensation ratios. The definition also provides that the district engineer may determine that compensation for temporal loss is not necessary when a mitigation project is initiated prior to or concurrent with the permitted impacts, except for resources with long development times (e.g., forested wetlands)". (2008 rule) (King and Price 2004)

1.1.5.2 Example/Representative Components

First, the historical aspect might be related to the assessment of the impact and the information available about historic conditions in the region. One element for the working group to consider is the messaging to the public around historic conditions. Next, restoration of degraded ecosystems often experience hydrological and biogeochemical time lags between the restoration implementation and ecosystem recovery and functional improvements. This lag will vary among habitat types based on the natural history characteristics of the species in the ecosystem. In addition, delays in a species' response to habitat modification can occur after restoration, when species or entire associated communities take longer to reoccupy or recolonize. The USACE 2008 mitigation rule does encourage higher amounts of compensatory mitigation to account for this concept of temporal loss. The challenge around this temporal lag as it relates to mitigation is that immediate loss on the impact site may not result in replacement of function on the restoration/mitigation site. Finally, ideal mitigation projects would continue to function under a range of potential future conditions associated with land use change and predicted by climate change models.

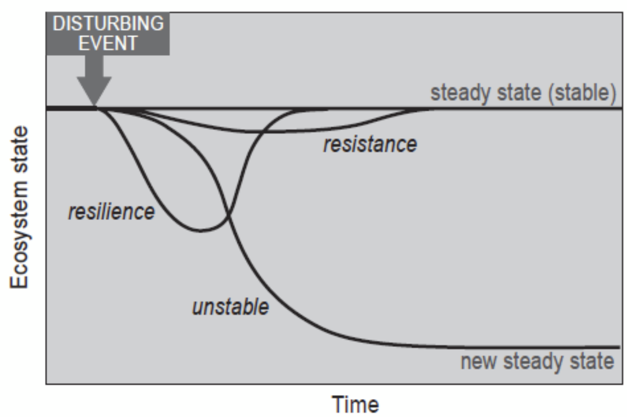

Fig. 2.3 Ecosystem responses to a disturbing event: resistance and resilience are modes of recovery, the unstable response implies a long-term disturbance which may or may not be reversible through restoration practices. Ecosystem state may be represented by productivity, species richness or other characteristics. Modified after Aber and Melillo (1991).

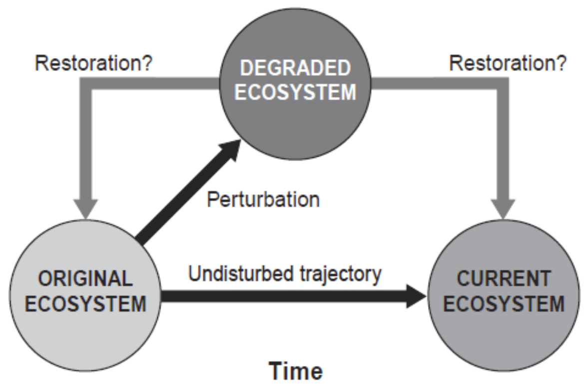

Fig. 1.5 Time changes an undisturbed ecosystem, making targets from the past hard to determine.

1.1.5.3 Utility (how might we us this; how might we calculate equivalency for this)

1.1.5.4 Research Needs

Conceptually, restoring fundamental processes should impart ecosystem resiliency under changing conditions. Research needs are identified below each bullet point.

- Historical condition (potential as a guiding principle)
  - Restored decisions are informed by an understanding of historic conditions
  - Go back as far as you can go since data was available and understand the trajectory
  - This does not necessitate making returning to those conditions a goal.
- Time to recover function or structure (long lead time)

    - Uncertainty
    - Higher mitigation ratios needed in planning?
- Future potential
    - Temporal modeling
- Potential for succession
    - Migration potential, transgression
    - Adaptability, resilience, persistence, stability
- Role of size (maybe move to landscape context, was also discussed in off site conversation in the context of combining several smaller mitigation projects into off site larger project)
    - Large areas provide room to accommodate landscape-scale processes and large, diverse populations. Larger wetlands correlate with greater species richness (Keddy et al. 2009), and are more resilient to disturbances (Moreno-Mateos et al. 2012). (From WRP 2018)

1.1.5.5 Relevance/Importance (why is this important)

Impacts are often instantaneous and permanent, but compensation often occurs over time. Moreover, there is uncertainty in the recovery trajectory and it is difficult to discern inherent and expected variability from deviations in expected response (especially early in the recovery process). Accounting for the time lag between losses and compensation and the uncertainty associated with this process is critical to ensure adequate compensation occurs. This may need to be revisited over the course of the recovery process as the ultimate disposition becomes clearer

An understanding of past condition, function, and services can be informative in determining expectations for the future ecosystem. The goal is not to recreate historic conditions, but to use the understanding of the past to inform actions and performance targets.

1.1.5.6 Example/Representative Metrics

- Accrual time
- Historic structure and composition
- Inherent annual variability
- Range of responses (measure of uncertainty)
- Organism traits (growth rates, reproductive cycle)
- Triggers in the process that might lead to adaptive management