



Midpeninsula Regional
Open Space District

R-21-31
Meeting 21-06
February 24, 2021

AGENDA ITEM 7

AGENDA ITEM

Preliminary Science Advisory Panel Findings on the Topics of Recreation and Monitoring, and a Contract Amendment to complete the Second Round of Scientific Review

GENERAL MANAGER'S RECOMMENDATIONS *den*

1. Receive a presentation on preliminary findings and work of the Science Advisory Panel related to the topics of Monitoring and Recreation.
2. Authorize the General Manager to execute a contract amendment with the San Francisco Estuary Institute to increase the contract amount by \$19,000, for an amended total contract amount of \$219,000, to address unforeseen costs due to COVID impacts and the need for additional coordination.

SUMMARY

The Science Advisory Panel (SAP), composed of the San Francisco Estuary Institute (SFEI) and Point Blue Conservation Science (Point Blue), provides an independent science-based review of land management topics to inform the Midpeninsula Regional Open Space District's (District) open space management decisions and practices. On August 28, 2019, the Board awarded a contract to SFEI for \$100,000 to complete the first round of scientific review and, if results were successful, authorized the option to amend the contract by an additional \$100,000 for a second round of scientific review. The SAP successfully completed the first round of work, including a scientific literature review of cattle grazing benefits and impacts, and is making progress on the topics of Monitoring and Recreation. For the Monitoring topic, Point Blue has worked with District staff to identify priority species and habitats that are feasible and informative to monitor at a landscape scale across District preserves, and provided recommendations for next steps in setting up a fiscally sustainable monitoring program. For the Recreation topic, SFEI has examined the scientific literature on the benefits of recreation in open space and found that the science demonstrates the physical and mental health benefits for open space visitors.

Based on the SAP's satisfactory progress to date, the General Manager will continue with the second round of work consistent with Board authorization and recommends increasing the contract amount by \$19,000 to address unforeseen costs due to COVID-19 disruptions, additional meetings and enhanced coordination requested by the District. There are sufficient funds in the Fiscal Year 2020-21 (FY21) budget for this amendment and additional funds will be proposed as part of the FY22 Budget and Action Plan.

BACKGROUND

On August 28, 2019 (R-19-120), the Board awarded a contract to SFEI and subconsultant Point Blue to form the SAP. These institutions were described at the 2018 Board Retreat (R-18-148) and further discussed by the Board on March 27, 2019 (R-19-32). The General Manager was authorized to enter into a contract with SFEI for a not-to-exceed amount of \$200,000, consisting of \$100,000 for the first round of research and an additional \$100,000 for a second round to be added to the contract at the General Manager's discretion upon satisfactory progress and demonstrated benefits.

The initial responsibility of the SAP was to prepare summary white papers on the following three key topics of interest to the District, as approved by the Board on January 8, 2020 (R-20-05):

Topic 1: How can the District effectively and efficiently monitor changes in priority plant and animal populations at the landscape scale?

Topic 2: What are the visitation and recreational use benefits and trade-offs to fulfilling District goals, including natural resource protection and ecologically sensitive public enjoyment and education?

Topic 3: Review cattle grazing benefits and impacts:

- What is the net climate impact of cattle grazing (e.g., potential increase in soil carbon minus cattle methane emissions)? What are the options, such as grazing regimes or dietary additives, to reduce emissions from cattle grazing?
- What are the current scientific results on the effectiveness of managing grasslands and reducing fire risk with cattle grazing?
- How does cattle grazing as a land management strategy compare to alternatives in achieving District goals including climate protection and what are the trade-offs?

Topic 3 is complete. Findings were presented to the Board on November 4, 2020 (R-20-129). Topic 1 ("Monitoring") and Topic 2 ("Recreation") are scheduled to continue through the summer of 2021. Preliminary reports on the Draft Monitoring Framework and Findings on Benefits of Open Space Recreation are included as Attachments 1 and 2. The Board will have the opportunity to select a fourth topic in March 2021; work on Topic 4 is scheduled to conclude by the end of 2021.

DISCUSSION

First Year Findings for Monitoring and Recreation Topics

Monitoring Topic

Point Blue, in partnership with a focus group of District staff, is developing a monitoring framework to address Board questions raised on this topic and to guide District monitoring efforts in the long term. Point Blue is drawing on peer-reviewed studies and methodologies to construct a monitoring framework tailored to District lands and needs. In the first year of work on this topic, Point Blue reviewed relevant documents regarding the District's biological resources, current monitoring practices, and goals, and hosted three virtual workshops with the District staff focus group. Based on the background documents and feedback from the focus

group, Point Blue developed draft monitoring objectives, a proposed list of priority species and habitats, and sample frameworks for monitoring at the landscape scale (see Attachment 1).

The group identified two goals for the monitoring program:

1. To understand the trends in priority plant and animal populations, and
2. To signal when more research is needed and/or when a management intervention is warranted.

The draft framework emphasizes that monitoring is not equivalent to research. Research is experimental, often seeks to determine causal relationships and does so by formulating a hypothesis to a specific question and using rigidly designed protocols to test that hypothesis. Monitoring is typically observational, broad in temporal and/or spatial scope, and can encompass multiple goals or objectives. This makes it better suited to guiding District management activities. In most cases, the purpose of District monitoring efforts would be to identify a change (e.g. in the distribution of a priority habitat or animal species) and/or signal when further, more rigorous research or a management intervention is needed.

The draft framework also describes potential pitfalls that the District should seek to avoid in developing a broad monitoring program. Typical pitfalls include prioritizing data collection over data management and analysis, failing to understand and transparently communicate the limitations of the data, and creating a program that is not sustainable because it exceeds the limits of available budget and staff time. Point Blue recommends an iterative process for developing a lasting and useful monitoring program; the programs efficacy should be reassessed at regular intervals and changes made as needed to ensure objectives are met.

As a final recommendation, Point Blue suggests the District may want to hire a fellow to take on the task of assessing our existing data and data structures, determine where and how community science could be leveraged, define thresholds, and develop methods for data analysis and reporting.

Recreation Topic

SFEI is conducting the research on this topic in two phases. In Phase I, which is complete, SFEI investigated the benefits to people associated with recreation in large, natural open spaces. In Phase II, which will commence in March of 2021, SFEI will investigate the ecological tradeoffs of recreation. Specifically, the SAP will present the state of peer reviewed scientific understanding regarding the types and scale of impact on the natural environment associated with recreational uses and suggest ways to apply cost-benefit analyses to land management and access decisions, e.g. by quantifying the point at which negative impacts to habitat, wildlife, or ecological functions outweigh the positive benefits to people and communities.

To date, SFEI has reviewed District materials related to public access and recreation and held two workshops with a District staff focus group. SFEI has also assessed over 80 peer-reviewed papers for the Phase I research, focusing on benefits to both physical and mental health and well-being from nature recreation. In the workshops, SFEI and District staff refined the research question, reviewed the selected scientific papers and discussed how the findings can apply to the District. Overall, SFEI reports findings that support the District's current understanding of the importance of open space access to human health and wellness (see Attachment 2).

There is broad scientific consensus that exposure to nature, whether in the setting of an urban park or larger more natural open space, benefits physical health and physical health behavior (e.g. lowering blood pressure, reducing the risk of asthma, increasing physical activity, etc.), mental health (e.g. reducing depression and anxiety, boosting self-confidence, etc.) and social health (e.g. sense of community or social cohesion). While many of the existing studies examine the effects of either urban parks or remote wilderness settings, SFEI concluded that it is reasonable to assume the same benefits would apply to the District's more uniquely situated preserves. SFEI included research on open spaces similar to the District's where available.

Large, biodiverse open spaces like District preserves also provide unique benefits. Compared to urban greenspaces, wildland preserves offer cooler temperatures, cleaner air, and lower noise and light levels. Simply being in a natural setting, even without participating in a specific recreational activity, has been found to have therapeutic effects. Larger open spaces are associated with higher levels of sustained physical activity, and in urban settings, greater biodiversity has been shown to correlate with improved attention span as well as overall health indicators such as average birth weight. Many studies also demonstrate a connection between nature experience and support for conservation. This is especially true of guided experiences with knowledgeable leaders.

Recommended Contract Amendment

The General Manager recommends amending the contract with SFEI by an additional \$19,000, which would bring the total contract amount to \$219,000, to address time delays and operational issues related to COVID-19 and accommodate additional coordination to ensure institutional learning during the SAP process and provide clear District direction on the scope of the topics and delivery of results. The additional funds will close out the three selected topics and allow for a fourth topic, which the Board will have the opportunity to select on March 10, 2021.

FISCAL IMPACT

The FY21 amended budget includes sufficient funds to complete work through the end of FY21. Funding to continue work next fiscal year will be requested as part of the FY22 Budget and Action Plan.

BOARD COMMITTEE REVIEW

This item is being brought directly to the full Board of Directors given full Board interest.

PUBLIC NOTICE

Public notice was provided as required by the Brown Act. Postcard mailings were sent on February 16, 2021 with an email follow-up on February 18 to recipients on Interested Parties lists for Hiking Access, Biking Access, Equestrian Access, Dog Access, ADA/Easy Access, Regional Trails and Natural Resources Management.

CEQA COMPLIANCE

This item is not a project subject to the California Environmental Quality Act.

NEXT STEPS

Pending Board approval, the General Manager will authorize the contract amendment. The SAP and staff focus groups will continue with the next phases of the Monitoring and Recreation topics. The next phase of work on the Monitoring topic will focus on engagement with partner agencies to better understand the scope of existing regional data, identify the interests and capacities of various stakeholders in a landscape-scale monitoring effort and develop a job description for either the District or a partner stakeholder to hire a fellow as recommended in Point Blue's report. The next phase of the Recreation topic will be a review of scientific literature regarding the tradeoffs (ecological impacts) of recreation in wildlands with synthesis to describe mechanisms by which the District could balance benefits and impacts to guide recreational access decisions. Both topics are expected to conclude with final presentations to the Board in summer or fall of 2021.

Moving forward, the aim will be to stagger topic schedules so that work is generally ongoing for only one topic at a time, with at most a few months of overlap while one topic winds down and the next is starting. This will increase staff availability to interpret and apply the SAP's findings to District policies and activities.

Selection of Topic 4

The contract with SFEI includes a fourth topic that the Board will have an opportunity to select on March 10, 2021. In addition to the list previously reviewed by the Planning and Natural Resources Committee (R-19-149), staff will present an option to expand the public access question to specifically look at the potential impacts of electric bicycles. Work on that topic would begin shortly after selection and continue through the end of the calendar year.

Attachment(s)

1. Monitoring Report
2. Findings on Benefits of Open Space Recreation

Responsible Department Head:

Kirk Lenington, Natural Resources Department

Prepared by:

Sophie Christel, Management Analyst I, Natural Resources Department

Contact person:

Sophie Christel, Management Analyst I, Natural Resources Department

RECOMMENDATIONS FOR MONITORING PLANT AND ANIMAL POPULATIONS AT THE LANDSCAPE SCALE

18 February 2021

Elizabeth Porzig¹, Thomas Gardali¹, Julie Andersen², Sophie Christel², Aaron Hebert², Kirk Lenington², Meredith Manning², Coty Sifuentes-Winter², and Erica Spotswood³

¹Point Blue Conservation Science, contact Elizabeth Porzig: eporzig@pointblue.org

²Midpeninsula Regional Open Space District, contact Sophie Christel: schristel@openspace.org

³San Francisco Estuary Institute, contact Erica Spotswood: ericas@sfei.org

Executive Summary

In July 2020, Point Blue Conservation Science, in partnership with San Francisco Estuary Institute and Midpeninsula Regional Open Space District (District) staff (collectively called the Monitoring Team) organized a series of structured conversations and surveys to develop recommendations for taking the first step to address the District's Board approved question:

“How can the District effectively and efficiently monitor changes in plant and animal populations at the landscape scale?”

To guide the monitoring recommendation process the Monitoring Team first defined the desired outcomes, agreeing that “an effective and successful ecological monitoring program on District lands will provide status and trend information on variation in plant and animal populations through time.” The team also identified the public, the regional land management community, and the District's Board and staff as target audiences and developed three guiding principles:

1. Have a clear plan for data intake, management, analysis, and interpretation;
2. Know the limits of the data; and
3. Design effective and efficient monitoring that will be sustainable.

In the context of the monitoring question and the framing concepts co-created by the Monitoring Team, District staff aligned on the following two objectives for monitoring:

1. To understand the trends in priority plant and animal populations (status and trends monitoring).
2. To signal when more research is needed and/or when a management intervention is warranted (threshold monitoring).

The following communities were judged important for monitoring: grasslands because of the grazing management that is occurring; ponds, creeks, and wetlands because of their high biodiversity; and forests because of fire; only saltmarsh was excluded as a priority habitat type given its limited extent. In sum, District staff recommend that as many ecological community types as possible be monitored at the landscape scale.

The following recommendations were made based on information collected through this process:

1. Survey the vegetation community across all District and/or regional lands on a regular interval. Our top recommendation is to monitor key components of the natural plant communities (a relatively affordable subset) every 5 years with the full components (e.g., lidar, fuels, water features, infrastructure) every 10 years.
2. Capitalize on existing efforts and combine forces with regional partners. The District's lands and its regional partners lands are already rich with data, be they from existing ongoing monitoring programs, past work, or from the continuous year-round data stream from citizen/community science programs. Hence, given the amount of data currently collected, we believe that the biggest opportunity for programmatic efficiency is to leverage existing data to generate biological trends and to inform the creation of population thresholds that will trigger further research and/or management action.

The opportunity to leverage community science data (e.g., iNaturalist) is on the leading edge of conservation and monitoring design, and the District with its regional network of partners are in a position to help lead this development.

3. The recommended specific approach for the District and its regional partners is to hire a postdoc for a two-year term to establish the monitoring program and produce initial results. There are many benefits of hiring a postdoc:
 - It is a term position and hence the investment for all parties is clear;
 - Postdocs are typically highly focused and can produce high quality products relatively quickly;
 - There is already a precedent of sharing a postdoc with the District's regional partners;
 - The nature of this work is highly technical and will require someone on the leading edge of data analysis to be successful;
 - Having someone "in-house" (versus consultant) allows greater access to resources (e.g., data and expertise) and can better link to the regional science and monitoring community.

Introduction

Ecological monitoring is an essential component of natural resource management. In light of ecological stressors such as climate change, invasive species, altered disturbance regimes, human disturbance, and habitat loss, ecological monitoring can provide natural resource managers with information on the status and trends of priority plants and animals to enable better decision making (Jaentos and Kenney 2015, Reynolds et al. 2016). Hence, in July 2020, Point Blue Conservation Science, in partnership with San Francisco Estuary Institute, and The Midpeninsula Regional Open Space District (hereafter Monitoring Team) organized a series of structured conversations and surveys to develop recommendations to begin to address the District's Board approved question: "How can the District effectively and efficiently monitor changes in plant and animal populations at the landscape scale?"

The complexity of natural ecosystems presents inherent challenges to the design and implementation of monitoring programs. Ecological processes (e.g., species dispersal, population dynamics), abiotic processes (e.g., weather), and human activities occur concurrently across the landscape. Ecological indicators can reflect all of these underlying mechanisms and as such are often characterized by a high degree of temporal and spatial variability. While ecological monitoring provides valuable insight into the status and trends of this variability, it is not necessarily appropriate to expect ecological monitoring to identify causes of a change in status or trend. The role of ecological monitoring is often to signal when further research or management intervention is warranted.

Despite the value that ecological monitoring data can contribute to resource management and decision making, it can also be fraught with challenges and can be prone to failure (Field et al. 2007). Awareness of the common causes of failure, including lack of trigger points for action, poor data management, and lack of resources to analyze and communicate the data, can contribute to effective design (Lindenmayer and Likens 2018). Given the potential risks and vulnerabilities of ecological monitoring and the financial investments needed, we recommend an adaptive approach wherein the value and efficacy of the monitoring program is evaluated on regular intervals to identify course corrections to be implemented when feasible and/or warranted (Lindenmayer and Likens 2009).

The Midpeninsula Regional Open Space District (District) has preserved nearly 65,000 acres of land on the San Francisco Peninsula and in the Santa Cruz Mountains Region. Broadly, the ecological communities encompassed by the lands of the District include grasslands, coastal prairie and shrubland, forests, wetlands, and tidal marsh. District lands are host to myriad common, endemic, and rare species of plants and animals and provide extensive open space access to the Bay Area community.

The purpose of this report is to summarize the process and recommendations made to-date and to provide recommendations for the District’s Board of Directors (Board) to consider for next steps. During this first phase, the monitoring team completed step 1 and part of step 2 of a monitoring design process recommended by Reynolds et al. (2016) (Figure 1). Subsequent phases of this project should include final design elements (completing step 2) and adaptive implementation (steps 3 and 4) of the monitoring program.

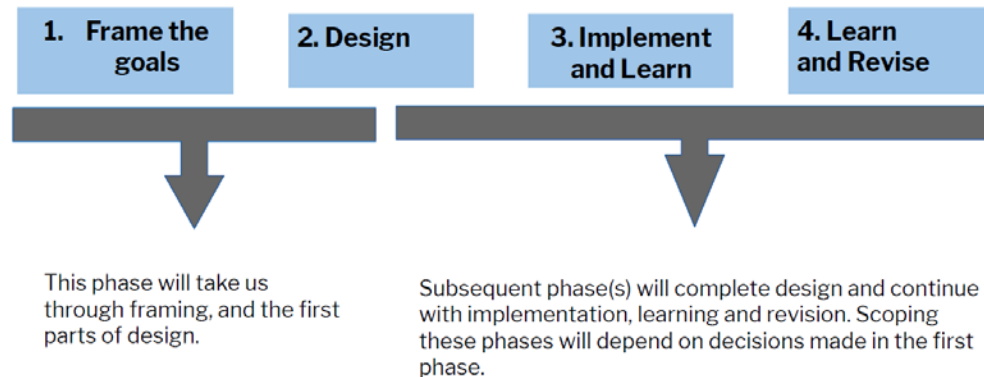


Figure 1: Overview of the design process for ecological monitoring. Adapted from Reynolds et al. (2016)

Framing the Monitoring Objectives

The framework for ecological monitoring should be designed within the context of the District’s mission: *“To acquire and preserve a regional greenbelt of open space land in perpetuity, protect and restore the natural environment, and provide opportunities for ecologically sensitive public enjoyment and education.”* On the San Mateo County Coast, the District’s mission includes: *“To acquire and preserve in perpetuity open space land and agricultural land of regional significance, preserve rural character and encourage viable agricultural use of land resources.”* Given the scope of these missions, and the diversity of landscapes the District stewards, there are many ecological communities that can be included in monitoring.

In the framing stage of this project, District staff identified key elements of a monitoring framework with regards to desired outcomes and target audiences. The Monitoring Team also discussed additional guiding principles that are discussed below.

Desired Outcomes. An effective and successful ecological monitoring program on District lands will provide status and trend information on variation in plant and animal populations through time. This data may be useful in several ways.

- Providing an integrated ecological context that is relevant across preserves and programs.
- Signaling when more research is needed and/or when a management intervention may be warranted.

- Supporting ‘no action’ scenarios in which management interventions are not taken.
- Contributing to research that identifies likely influences of ecosystem drivers such as climate change, species invasions, and management actions.
- Telling natural resources “stories” about the local environment to educate the public as part of the District’s mission.

Target Audiences. District staff identified three primary audiences for the monitoring data.

- *Public.* Monitoring data should be summarized and made available to the public on regular intervals.
- *Regional land management community.* Monitoring should be designed and conducted in a way that the results and conclusions are relevant to the broader regional land management community. Opportunities to coordinate data collection and analyses can provide pathways for coordinated decision-making and have the potential to increase impact of management and conservation actions.
- *Board and staff.* Monitoring can provide District board and staff with greater qualitative and quantitative familiarity with District lands which can support effective stewardship, and inform project planning and decision making.

Additional Guiding Principles. In addition to the above guiding elements, the Monitoring Team discussed the following principles that should guide the monitoring program:

- *Have a clear plan for data intake, management, analysis, and interpretation.* One of the most common pitfalls of ecological monitoring is that because budgetary and staff resources can be scarce, data collection is prioritized at the expense of data management, analysis, and interpretation and the stories of the data go untold. Among the most important elements of a monitoring program is a clear plan and commitment to analyzing and reporting the data on regular intervals. To this end, it is vital to collect only data that are needed for the objectives and to have a good data management plan in place (Sutter et al. 2015).
- *Know the limits of the data.* Be clear about what the data can - and cannot - say. Any single ecological monitoring program will not reveal all we want to know about natural communities. Given the observational nature of most monitoring programs, understanding mechanisms of change is not a reasonable expectation of monitoring. It is most appropriate to think of monitoring as an early detection system that can signal when further research or a management intervention are needed (Davies and Gray 2015).
- *Design effective and efficient monitoring that will be sustainable.* Many monitoring programs are intended to continue for long periods of time, and many fail. One main reason for failure is that the program is overly costly or complicated (Caughlan and Oakley 2001). Successful monitoring programs are efficient by design. Efficiencies can include leveraging some of the many existing and on-going data collection efforts currently managed by District staff and partner agencies, including compliance monitoring and data contributed by volunteers and community members.

While these data collection efforts were not designed for this purpose, there are examples of the flexibility of monitoring in addressing emerging questions (Porzig et al. 2011). This is discussed further below.

Monitoring Question and Monitoring Objectives. The overarching monitoring question was developed prior to this process by Point Blue Conservation Science, San Francisco Estuary Institute, and District staff, and was approved by the District Board: **How can the District effectively and efficiently monitor changes in plant and animal populations at the landscape scale?** This question, while broad, does provide specific guidance that this recommendation framework will *only* focus on plants and animals (versus ecological processes) that have been prioritized by the Monitoring Team (see below) and that inference will be at the landscape scale and hence may not provide robust information at smaller scales and hence may be insufficient for plants and animals with limited distribution and/or small populations. The monitoring team did judge that future efforts to monitor ecological processes may be important to monitor large-scale stochastic changes such as landslides, wildfire, or the cumulative effects from land-use change but that was beyond the scope of this phase.

In the context of the monitoring question and the framing concepts co-created by the Monitoring Team, District staff aligned on the following two objectives for monitoring:

1. **To understand the trends in priority plant and animal populations** (status and trends monitoring)
2. **To signal when more research is needed and/or when a management intervention is warranted** (threshold monitoring)

These objectives will inform sampling design, analysis, and communication of the data and results.

Monitoring Design

In conjunction with the identification of objectives of monitoring for the District, the group discussed several design elements that are relevant to decision making within the monitoring framework. These elements include identifying existing relevant data collection, identifying the spatial scope of monitoring, differentiating between the different types of monitoring and research, creating a conceptual framework (Figure 2), and identifying taxa to monitor.

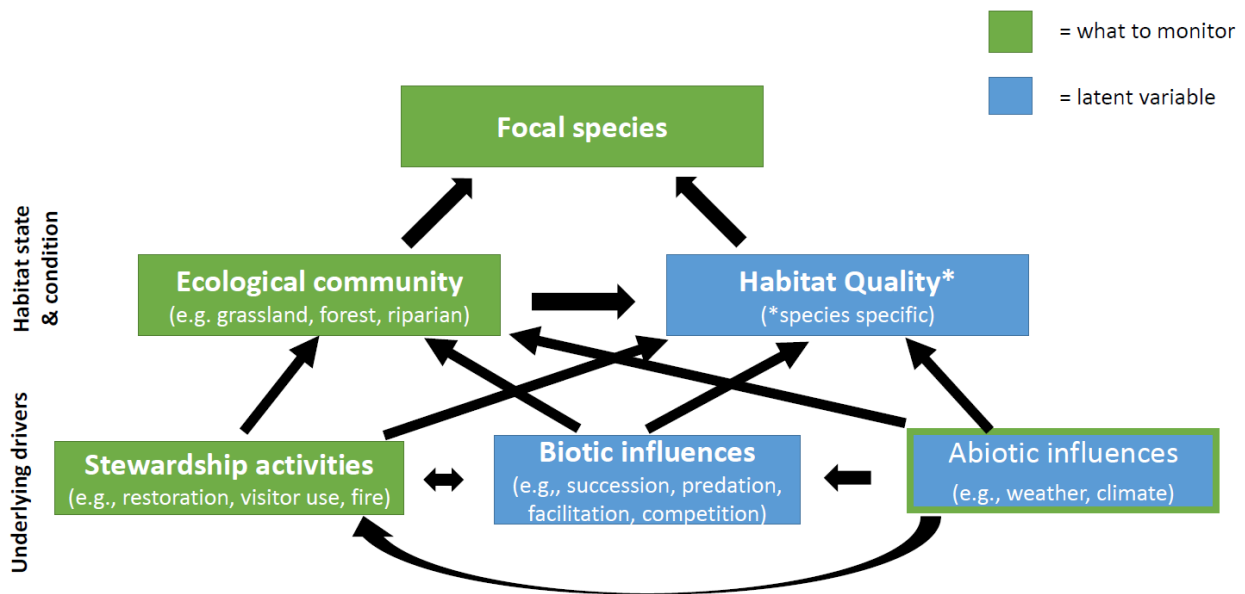


Figure 2. A conceptual model describing the relationship between elements of the ecosystem relating to trends and thresholds. The diagram shows three general categories of underlying drivers of ecological change: stewardship activities, biotic influences, and abiotic influences. These interact with each other and, in part, determine the type of ecological community and the degree to which that ecological community confers fitness to the organisms that live among it (i.e., habitat quality). Focal species are a subset of the ecological community that are chosen to monitor because they are efficient to study and are representative of the broader community. In service of trend and threshold monitoring, the green shaded boxes show which elements of the system should be measured.

Existing Data Collection Efforts. District staff currently oversee many different individual monitoring programs that serve distinct and separate purposes. These programs are predominantly focused on special status species inventory and/or recovery (e.g., red-legged frog, *Rana draytonii*) and monitoring for compliance purposes (e.g., mitigation requirements). While the sampling design and location of these monitoring programs may preclude their relevance to the objectives of this program, it is possible that some of these data can inform the broader ecological monitoring goals of this program. The potential for broader application and utility of data that is already being collected to create efficiencies warrants close consideration of these data sources. A worthwhile next step may be to evaluate the ability of these data to be summarized from the perspective of status and trends of particular species and the potential to inform threshold monitoring.

In addition to the data collected by District staff for other specific purposes, a large amount of data are also collected on District lands through outside researchers and community science (a.k.a. citizen or community science) programs. The growing popularity of programs such as iNaturalist, eBird, and CALeDNA are opening up new possible data sources for natural resource managers (e.g., Callaghan and

Gawlik 2015, Meyer et al. 2019, Whitman et al. 2019). While iNaturalist data is already being used by District staff for specific projects (e.g., invasive species presence, to time rare plant surveys, permitting), recent advances in data analytics to account for sources of variation and bias are opening up new potential uses for these data. For example, SnapShot CalCoast is an early warning and forecasting system designed to monitor key indicators of biodiversity among California Marine Protected Areas. The development of quantitative tools that correct for lack of standardization across space and time have enabled the use of iNaturalist data for the purposes of status, trend, and threshold monitoring (Rapacciuolo et al. 2017). Indeed, given some of the recent statistical advances in the use and application of iNaturalist data, it is quite likely that this tool will be increasingly called upon to inform conservation decision making, and the District is well-positioned to continue to be a part of this development. Furthermore, community science programs like CALeDNA can monitor organisms not well sampled by other methods (e.g., soil microbes, rare species) and as such could be a good complement to visual and auditory methods (Meyer et al. 2019).

Spatial Scope of Monitoring and Prioritization of Habitat Types. In light of the many existing monitoring efforts that occur on District lands for compliance and specific project purposes, the emphasis of this project is the landscape scale of District lands. The District landscape encompasses several ecological communities. A portion of our Monitoring Team workshops was focused on discussing the relative importance of different District natural communities in stewardship decision making. District staff discussed the relative merits of the major types to help focus monitoring efforts. In sum, the following communities were judged important: grasslands because of the grazing management that is occurring; ponds, creeks, and wetlands because of the high biodiversity in them; and forests because of fire; only saltmarsh was excluded as a priority habitat type given its limited extent. In sum, District staff recommend that as many ecological community types as possible be monitored at the landscape scale.

A Closer Look at the Complementary Roles of Research and Monitoring. Through the course of the workshops, discussion of the differences between research and monitoring came up several times and warrant consideration here. Research and monitoring are different but complementary forms of scientific inquiry (figure 3). Research is typically focused on a single specific question, is relatively short-term, and can include manipulative experiments that are designed to elucidate causal mechanisms. Monitoring, in contrast, is often broad in temporal or spatial scale, and is typically observational, and repeats data collection over a long period of time. As such, monitoring often does not answer questions of mechanisms or attribution directly, but is more appropriately considered to be an early warning system that can trigger further research or action. A classic example of the complementary roles of monitoring and research is the decades-long monitoring of the Keeling curve of atmospheric carbon dioxide at Mauna Loa and the complementary research that provided attribution of this change to anthropogenic activity (Keeling and Whorf 2005).

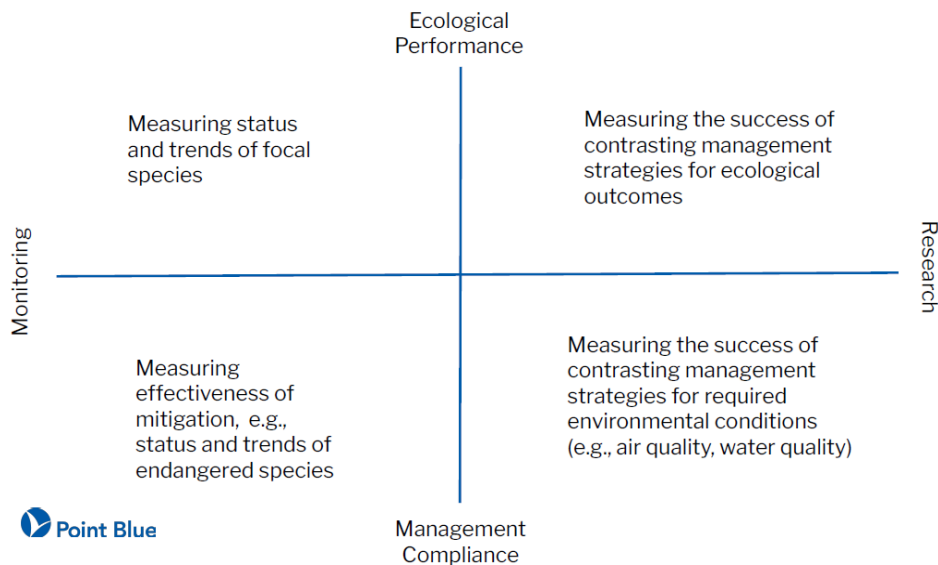


Figure 3: Conceptual diagram showing the contrasting relationships between monitoring and research and ecological performance and management compliance measurements. Examples of different types of data collection that vary across these two axes are provided.

In addition to the differences between research and monitoring, the Monitoring Team also discussed the differences between data collection that is focused on management compliance as opposed to data collection that is focused on ecological performance. Compliance monitoring most often stems from regulatory requirements and often concerns a single species such as an endangered species, or a critical habitat, such as monitoring that is associated with habitat mitigation. In contrast, ecological performance monitoring can include groups of relatively common species, often referred to as focal species, and is typically motivated by a desire to understand patterns in species occurrence more broadly. Given the different purposes of compliance monitoring and ecological performance monitoring, the sampling designs that support these two forms of inquiry can preclude the application of data from one to the other. However, this is not necessarily the case, and depending on the geographic scope of compliance monitoring, data can often be applied to multiple purposes.

Selecting Taxa to Monitor. A primary focus of the second and third workshop was the discussion of prioritization of plant and animal taxa. The Monitoring Team went through several exercises to identify criteria to use in evaluating the relative strengths and weaknesses of potential priority species. These criteria included:

1. *Landscape Occurrence.* The taxonomic group or species can be found on the majority of Midpen lands.
2. *Major Ecological Importance.* The taxonomic group or species is likely to have a major role in protecting or enhancing the structure or function of a local ecosystem and/or the abundance or stability of another species or taxonomic group. Decline or loss would have deleterious consequences for a local ecosystem or for another species or taxonomic group.

3. *Ease of Detection.* The species or the majority of species with the taxonomic group can be easily identified from similar species with minimal training and probability of detection is high.
4. *Existing Monitoring Programs.* The taxonomic group or species is well covered by an existing monitoring program with freely available protocols and data management systems. Implementing these programs would require investing in someone to implement and coordinate this effort internally and perhaps with regional partners.
5. *iNaturalist or eBird.* The taxonomic group or species is well sampled by community science programs. Monitoring with these programs would require investing in training, data analysis and coordination functions.
6. *Economically Feasible.* All aspects of the monitoring program from data collection to data interpretation and presentation can be accomplished for \$100k or less annually. This value was provided by District staff as an estimate of resources that might likely be available.

The Monitoring Team discussed the relative merits of approaches that focus on monitoring individual at-risk species, common species, taxonomic groups, ecological communities, or combinations of these. We used the above criteria to guide these conversations acknowledging that ultimately what to monitor is a product of the District's values and priorities.

A critical consideration that emerged during these discussions, and one that reflects District staff's guidance that monitoring be economically feasible, is that the choice of what to monitor be efficient and should limit the need for additional time of existing staff. Point Blue fully concurs with this desire as it is our experience that monitoring program efficiency is related to long-term sustainability.

District staff expressed interest in monitoring species likely to be most impacted by climate change and open to any combinations that will be useful for management purposes. Of the many options discussed a focus on plant communities appeared to have the most support followed by pollinators. In sum however, it appeared the desire of District staff was to maximize monitoring for as many taxa as possible, from at-risk to common, in as many ecological communities as possible.

Recommendations

The following recommendations are based on the information gathered at each workshop, from the District provided information on current and past monitoring efforts, our general research on ecological monitoring, and on Point Blue's extensive experience designing, implementing, and maintaining long-term monitoring programs.

Survey the Vegetation Community Across All District Lands on a Regular Interval. Our top recommendation is to monitor key components of the natural plant communities (a relatively affordable subset) every 5 years with the full components (e.g., lidar, fuels, water features, infrastructure) every 10

years. Such mapping efforts are foundational to resource management as they can detect changes in the landscape over time and they can be used to understand changes in wildlife populations, target management actions such as fire and flood hazards, identify priority areas for habitat restoration, improve climate change resilience, and so much more.

Capitalize on existing efforts and combine forces with regional partners. The District's lands are already rich with data, be they from existing ongoing monitoring programs, past work, or from the continuous year-round data stream from citizen/community science programs. Additionally, the District's regional partners have existing data and similarly data are being collected by citizen/community science programs on their lands. Hence, given the amount of data currently collected, we believe that the biggest opportunity for programmatic efficiency is to leverage existing data to generate biological trends and to inform the creation of population thresholds that will trigger further research and/or management action. Combining forces may also allow cost sharing among regional partners and hence greater economic efficiency for all. Further, because of the lack of a strong prioritization signal from District staff toward particular taxa or groups of taxa, community science can be explored to assess trends for multiple species. Additionally, using existing community science programs has built-in data management and curation capabilities which is a major cost savings. Finally, these community science programs can also enable larger-scale analyses (e.g., to put results from District lands in context with the region or the state) and they are actively building and displaying powerful data analyses and resultant visualizations.

The opportunity to leverage community science data (e.g., iNaturalist) to inform trend and threshold monitoring is on the leading edge of conservation and monitoring design, and the District with its regional network of partners are in a position to help lead this development. Such an investment would not only open up the opportunity to create a robust, efficient and sustainable monitoring system, but would also position this system to tie in well with other ecological monitoring efforts at various scales.

We recommend that the District and its regional partners hire a postdoc for a two-year term to:

1. Catalogue all existing datasets;
2. Evaluate the degree to which iNaturalist and eBird along with the data already being collected for specific purposes (e.g., compliance, mitigation) can be applied to the specified monitoring objectives;
3. Develop biological thresholds which if crossed could trigger investment in research and/or management action;
4. If necessary, make recommendations for how to bolster community science efforts to better meet monitoring objectives (e.g., coordinate special surveys to be conducted by community scientists, set up CALeDNA plots and recruit community scientists);
5. Develop and publish (e.g., GitHub) code necessary to extract and analyze monitoring data; and
6. Conduct trend analyses and produce results the will help tell the story of the impact of the District's work.

There are many benefits of hiring a postdoc over other options like a consulting firm including: (1) that it is a term position and hence the investment for all parties is clear, (2) postdocs are typically highly focused and can produce high quality products relatively quickly, (3) there is already a precedent of sharing a postdoc with the District's regional partners, (4) the nature of this work is highly technical and will require someone on the leading edge of data analysis to be successful, (5) having someone "in-house" (versus consultant) allows greater access to resources (e.g., data and expertise), and (6) can better link to the regional science and monitoring community (versus a consultant).

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Photo by Karl Gohl, courtesy of Midpeninsula Regional Open Space District

An examination of the costs and benefits of visitation and recreational use of public open space

PART I: BENEFITS OF EXPERIENCES IN NATURE



SFEI San Francisco
Estuary Institute



PREPARED BY

San Francisco Estuary Institute
with support from Point Blue Conservation Science

PREPARED FOR

Midpeninsula Regional Open Space District

AUTHORS

Stephanie Panlasigui, SFEI
Erica Spotswood, SFEI

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An Examination of the Costs and Benefits of Visitation and Recreational Use of Public Open Space

PART I: BENEFITS OF EXPERIENCES IN NATURE

Prepared for Midpeninsula Open Space District by the San Francisco Estuary Institute with support from Point Blue Conservation Science

Executive Summary

The Midpeninsula Regional Open Space District (hereafter “Midpen”) manages 65,000 acres of land in Santa Clara and San Mateo Counties. Slightly less than half of this land, 31,000 acres across 26 open space preserves, is open for public recreation. Midpen’s mission for the management and protection of these lands is: “To acquire and preserve a regional greenbelt of open space land in perpetuity, protect and restore the natural environment, and provide opportunities for ecologically sensitive public enjoyment and education.” This joint mission creates a tension between public use and natural resource protection that is not unique to Midpen; many in the fields of conservation and land management struggle with this same tension. To make science-based management decisions that accomplish both goals, managers and planners must weigh the myriad public health benefits conferred by public access and recreation against a suite of potential detrimental impacts.

Public use has many known negative impacts on protected areas, including trampling of vegetation, alterations to the behavior of wildlife, impacts of domestic animals on wildlife, unsanctioned trail creation, removal of rare plants, and litter. Also, there are many health benefits to be gained from being outside and recreating in nature. Living in urban environments has a number of negative consequences for human health, often leading to disconnection from nature, sedentary lifestyles, and greater exposure to air pollution and other pollutants (McDonald et al., 2018). Midpen lands represent some of the largest and most biodiverse natural areas immediately adjacent to Santa Clara and San Mateo counties, with a population of more than 2.6 million people, and thus represent a critical resource to reduce some of the negative impacts of urban living. A comprehensive understanding of the benefits and tradeoffs of nature access can help to ensure that future visitor management decisions fulfill Midpen’s dual mission of protecting natural resources and allowing for public enjoyment of preserves.

To comprehensively evaluate both benefits and impacts, this project will span two years, and will produce two reports. Here, in the first report, we provide a synthesis of the peer-reviewed scientific literature on the associations between nature and health. The consensus is that nature, whether in a smaller urban park or in a larger open space, provides benefits to health behavior, physical health, mental health, and social health. Natural areas tend to impart benefits for a number of reasons: (1) natural areas are a refuge from air and noise pollution in cities, (2) their large size encourages more physical activity and promotes feelings of escape and solitude, (3) they tend to be biodiverse, which supports mental health, and (4) they provide views of special natural resources that promote

a sense of awe and general well-being. Accessibility and moderating factors (e.g., income level, race, gender) influence the magnitude of benefit an individual may receive. Studies have also highlighted significant links between experiences in nature and continued public support for conservation.

A small subset of the nature-health literature is specifically focused on recreation in large open spaces, referred to as wildland recreation. These studies have found that each type of recreational activity is associated with its own set health outcomes. Some activities, in particular hiking, are more commonly studied than others, perhaps due to relative popularity among recreationists. As new research continues to emerge, there may be more to learn about the potential health benefits of specific recreational activities.

In the second report, we will provide a summary of the literature on the negative ecological impacts of visitation and recreation in public open space. We will evaluate existing decision-support tools, such as the visitor use management framework used by federal agencies like the National Park Service, and other resources that evaluate the tradeoffs and benefits associated with public use. We will also consider what additional information may be needed to determine under which conditions the negative impacts outweigh the benefits. For example, a land manager may find public access acceptable as long as the benefits to people are greater than the negative ecological impacts (Figure 1). However, benefits may begin to erode as visitor experience declines with increased crowding (Grau and Freimund, 2016), and ecological impacts may be large relative to benefits when visitor density is high (Figure 1). Together the two reports will provide critical information for assessing tradeoffs between health benefits and negative ecological impacts of open space visitation.

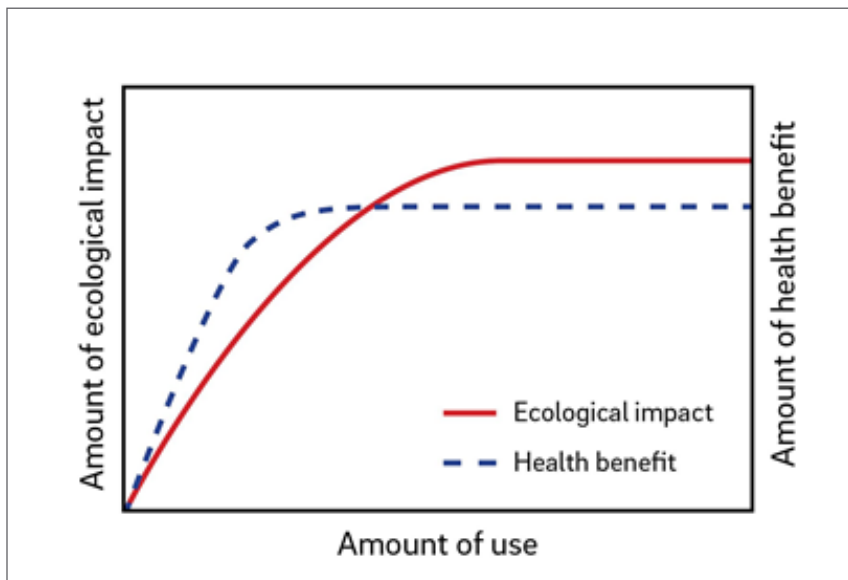
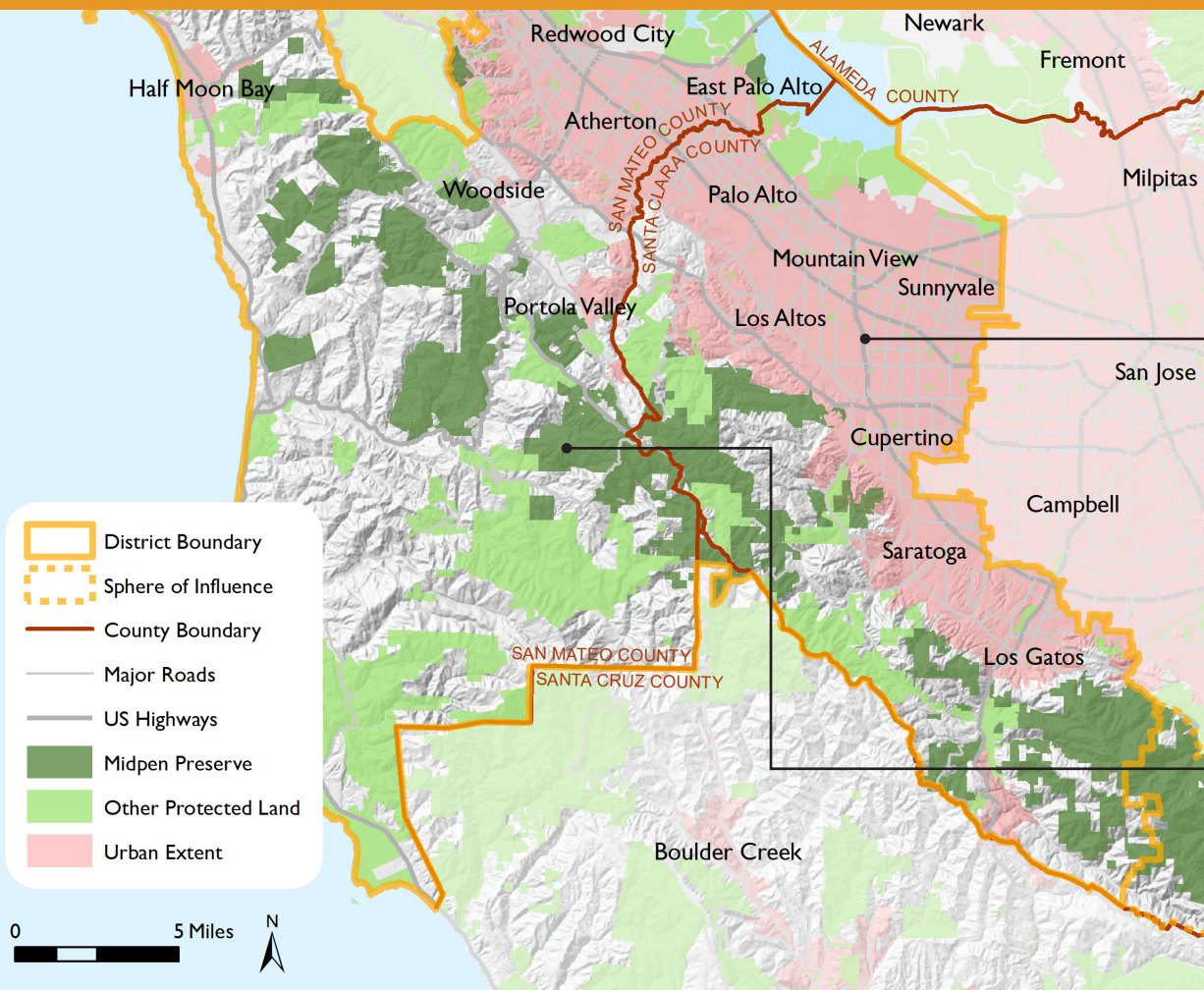


Figure 1. Conceptual framework for considering tradeoffs of impact and community benefits of public access to Midpen preserves. Ecological impact curve adapted from (Cole, 2004).

THE UNIQUE ROLE OF MIDPEN'S PRESERVES

Midpen's preserves offer a large urban population access to expansive, biodiverse, and relatively undeveloped areas for a variety of recreational activities. Due to these characteristics, the preserves play a role that is complementary to local, smaller urban parks (Figure 2). The preserves provide access to unique natural features and expansive views, regional relief from urban heat islands, and likely support higher levels of physical activity and mental restoration. Therefore, the preserves are serving a crucial function for local people by providing these substantial regional benefits. Additionally, providing public access likely contributes to cultivating public support for conservation efforts. In the second phase of this project, we will explore the potential negative impacts of recreation activities to biodiversity, ecology, and visitor experience. Together the two reports will provide critical scientific information for weighing tradeoffs between negative ecological impacts and health benefits.

Accessibility of Midpen's preserves has an impact on what proportion of the population can use the preserves. The health benefits a person can gain from nature depends on their ability to get there in the first place. A lack of public transportation options is a known limitation to access. Accessibility also includes informational resources at the preserve to help guide visitors (e.g., brochures in languages spoken by the community, directional signage, natural and historical resources information). While recent surveys conducted by Midpen gathered important information about visitor experiences, future surveys can help Midpen to better understand who in the service area is not visiting the preserves, and therefore who is not receiving the health benefits of nature experiences. There is a growing body of scientific literature on equity in nature access, which is an area of research Midpen may wish to pursue to better understand which communities are underserved and how better to engage as part of Midpen's diversity, equity, and inclusion efforts.



Smaller urban parks and general urban greening provide localized benefits to urban residents.

- Local cooling
- Air pollution capture
- Runoff reduction
- Mental and physical health benefits

Large, biodiverse open spaces provide regional benefits.

- Greater cooling effect during heat waves (regional refuges)
- Greater physical activity levels and health outcomes
- Greater mental health outcomes

Human health outcomes from nature experience

Over the past two decades, there has been a growing interest in the fields of public health, epidemiology, medicine, and psychology in the various ways experiences with nature improve human health and well-being. This science has grown rapidly, and there are now thousands of scientific papers on the topic (Bratman et al., 2019; Hartig et al., 2014; Kondo et al., 2018; Kuo, 2015). To some extent, nature appears to deliver health benefits no matter in what form people experience it, though we will discuss the nuances to this. While the majority of nature-health research focused on benefits gained by urban residents, studies focused on rural areas show that the results are similar for rural populations (Dennis and James, 2017; Mitchell and Popham, 2007), and therefore many of the findings from urban landscapes can reliably be assumed to be transferable to non-urban contexts. There is also a small subset of studies on expansive natural areas similar in form and context to Midpen's preserves. Given the great volume of literature, we conducted a review of some of the available studies and review articles across the broader nature-health field, then focused on the subset of studies and review articles specific to recreation in large natural areas as the most similar comparison available to Midpen's preserves.

As evidence of nature's benefits to human health has accumulated, researchers have pursued an understanding of how and why benefits are conferred. In a comprehensive review, Shanahan et al. (2016) identified four broad categories of human health outcomes from nature according to the current literature: mental health, physical health, health behavior, and social health (described in detail below). These four categories are not mutually exclusive. They can overlap and influence each other through feedback processes, i.e., enhancement in one category can elicit positive change in another category.

MENTAL HEALTH BENEFITS OF NATURE EXPERIENCE

A growing body of empirical evidence reveals the value of nature experience for mental health (Bratman et al., 2019). The scientific evidence has reached a consensus that: (1) nature experience is associated with psychological well-being; (2) nature experience is associated with reduced risk and lower burdens of some types of mental illness; and (3) opportunities for some types of nature experience are decreasing in quality and quantity for many people around the globe (Bratman et al., 2019). The "extinction of experience" due to urbanization, whereby urban residents grow removed from personal contact with nature, is a growing concern as the consequences include loss of health and well-being benefits of nature and a decline in pro-environmental attitudes and behavior (Cox et al., 2017a; Soga and Gaston, 2016). One of the most well studied pathways from nature experience to human health outcomes is attention restoration, or the recovery from stress and attention fatigue (Mayer et al., 2008). Mental health benefits of nature experience are numerous, for example:

- Walking in nature is restorative and improves mood and cognitive function (Gidlow et al., 2016)
- Walking in nature reduces symptoms related to depression (Bratman et al., 2015)
- More nearby nature leads to reductions in depression, anxiety and stress (Cox et al., 2017b)

HEALTH BEHAVIOR AND PHYSICAL HEALTH BENEFITS OF NATURE EXPERIENCE

Studies indicate that natural areas encourage health behavior, i.e., natural areas provide a venue and a motivation to engage in physical activity (Shanahan et al., 2016b). In part as a result of engaging in health

behavior, people improve their physical health, and may also see benefits in the mental and social health categories. The natural environment also appears to enhance the benefits of physical activity, compared to the benefits if the same activity were conducted in an urban environment (Shanahan et al., 2016b). The following are examples of positive health behavior and physical health outcomes:

- Children with more nearby greenspace spend more time being physically active (de Vries et al., 2007).
- Parks and natural resource areas are associated with more time spent being physically active (Cohen et al., 2006).
- Park users have better cardiovascular health (Grazuleviciene et al., 2015; Paquet et al., 2013)
- Higher neighborhood greenness is associated with higher survival rates after a stroke (Wilker et al., 2014)

SOCIAL HEALTH BENEFITS OF NATURE EXPERIENCE

Studies show that greenspaces facilitate social interactions, thereby fostering community attachment (i.e., the emotional connection between residents and to their place of residence) and neighborhood satisfaction (Larson et al., 2016; Lee and Maheswaran, 2011). Studies specific to recreational experiences in nature have found a range of social health benefits, including an increased sense of community, group cohesion, teamwork, empathy, and cooperation (Holland et al., 2018). The following are examples of positive social health outcomes:

- Greenspaces can strengthen sense of community among residents (Maas et al., 2009)
- Park quantity contributes to physical and social health, as well as overall well-being (Larson et al., 2016)
- Perceived greenspace quality and quantity can foster community attachment (Arnberger and Eder, 2012)

MODERATING FACTORS

While there is consensus in the literature that nature benefits mental, physical, and social well-being, the impact is not equal for all individuals. A suite of potential moderating factors influence the ways in which people interact with nature and whether people benefit from nature (Hartig et al., 2014; Shanahan et al., 2015). These factors include socioeconomic status, gender, ethnicity, age, and physical ability.

Moderating factors also include the physical accessibility of the public open space. As an individual must be able to get there in order to experience and benefit from nature, distant locations, lack of public transportation, and lack of parking are prominent physical access barriers to use of parks (Gibson et al., 2019). Other barriers to access include the perceived safety of a park, which has variable impact on park use across genders and ethnicities (Carlson et al., 2010; Lapham et al., 2015); and how appealing or welcoming a park seems to the community (Gibson et al., 2019). During a visit, conventional trail design can be a physical access barrier, e.g. to persons with mobility differences, and new design strategies for “all persons trails” or “universally designed interpretive trails” can help to reduce this barrier (Gertz et al., 2016).

What benefits are specific to natural areas?

Natural spaces found in parks and preserves adjacent to urban areas can provide unique resources to urban residents. For many urban residents living on the peninsula and in Silicon Valley, Midpen lands provide the closest opportunity to visit a natural space that is biodiverse, large, and relatively undeveloped. While much of the research connecting nature to human health has been conducted in urban areas, a subset of research specific to wildland areas highlights the unique health benefits that larger, more natural open spaces can provide. In this section, we identify the health benefits specific to natural areas, including escape from unhealthy environments found in cities, access to biodiversity, expansive views, and other natural features, and opportunities for recreation which can provide their own set of health benefits.

NATURAL AREAS PRESENT A HEALTHIER ENVIRONMENT

Natural spaces present a healthier environment in which to recreate, exercise and generally spend time (Markevych et al., 2017; Shanahan et al., 2016b). The scientific literature describes multiple pathways, one of which is that natural spaces are a refuge from various stressors found in urban environments. Air temperatures tend to be higher within cities, a phenomenon known as the urban heat island (Voogt and Oke, 2003), and natural environments provide a respite from excessive heat, due to the higher albedo (the reflection of sunlight) of vegetation and the cooling effect of evapotranspiration. Air pollutant concentrations tend to be lower in and around greenspaces, in part due to the absence of most emissions sources within greenspace, i.e., vehicular traffic (Markevych et al., 2017). Open spaces are also quieter than more developed areas, due to buffering effects of vegetation (Markevych et al., 2017).

Simply being in nature, even without participating in activities such as hiking, horseback riding, or mountain biking, has a therapeutic effect. Compared to an experience in an urban setting, an experience

Horseback riding. (photo by Randy Weber, courtesy of Midpeninsula Regional Open Space District and CC BY 2.0)



in forest environments leads to significantly improved attention capacity, as well as lowered heart rate, lower blood pressure, and better mood (Sonntag-Öström et al., 2014). Some studies also show that passively experiencing natural elements near to an individual's home affects human health. More greenness around one's home is associated with higher birth weights (Dzhambov et al., 2014), lower risk of myocardial infarction (Yitshak-Sade et al., 2017), and reduced levels of depression and anxiety (Beyer et al., 2014). A classic study by Ulrich (1984) found that views of nature from hospital windows may influence post-surgery recovery times. Furthermore, environmental biodiversity has been associated with immune function via support of beneficial microorganisms living on skin and in the gut (Kuo, 2015). For instance, a study in Finland found species richness of uncommon native flowering plants to be associated with reduced allergy response, by means of supporting higher diversity of bacterial flora on a person's skin (Hanski et al., 2012). Nearby habitat diversity has been associated with good general health (Wheeler et al., 2015), and a lower risk of asthma in children (Donovan et al., 2018).

NATURAL AREAS ARE LARGE

While the nature-health literature has grown to a vast body of work, there is only a small subset of these papers focused specifically on the experience of wildland recreation and its health outcomes (as opposed to more general urban greening and city park recreation). Hammitt et al. (2015) described the key characteristics of wildlands as:

- dispersed over large areas, and often having low use density compared to designed recreation areas;
- those in which the environment for activities is of greater importance than in developed recreation situations;
- largely natural, where management strives to maintain a natural appearance; and
- limited in facility development extent and function.

Compared to studies on health and urban nature, the subset of studies on health and wildland experiences may be of elevated interest, given the size and expansiveness of Midpen's network of preserves. In a recent review of 113 wildland recreation studies, 33% of studies focused on physical health impacts and 84% focused on mental health impacts (Thomsen et al., 2018). A complementary review of 235 studies explored trends of psychological, social and educational outcomes associated with wildland recreation (Holland et al., 2018). The vast majority of wildland recreation and health studies were published in the last 20 years (Thomsen et al., 2018). Our understanding of the potential unique benefits of experiences in wildlands compared to urban nature will continue to deepen as more research continues to emerge.

The large size of natural areas likely plays a role in enhancing health outcomes. The lack of interruptions (e.g., road intersections) to walking in larger parks allows visitors to sustain both a higher level of physical activity and a longer duration of physical activity (Sellers et al., 2012), supporting better cardiometabolic health (Paquet et al., 2013). While these findings were derived from examination of size variation among urban parks, we expect this trend to translate and be true of wildland settings as well. Furthermore, wildlands can provide unique opportunities for solitude and nature immersion (Holland et al., 2018), possibly due to their large size. Wildland settings make it possible for visitors to perceive escape and solitude, which appears to have an important influence on a variety of health outcomes (Holland et al., 2018; Thomsen et al., 2018).

NATURAL AREAS TEND TO BE BIODIVERSE

Visiting more highly biodiverse parks can confer greater mental health benefits. Studies have found that greater species richness (among birds, bees, butterflies, and plants) is positively correlated with better attention restoration among visitors to parks (Wood et al., 2018; Fuller et al., 2007). Meanwhile Dallimer et al. (2012) found that, regardless of a park's actual species richness, people achieve better attention restoration in parks they perceive as biodiverse.

Parks with high native biodiversity may also encourage physical health by drawing more visitors, although ecological knowledge mediates this effect. Shanahan et al. (2015) found that people with stronger connections to nature are more likely to travel to visit parks with high canopy cover and large areas of remnant native vegetation. Meanwhile, parks with visible ecological deterioration, such as forests invaded by pine beetles in Colorado and Minnesota, may be less appealing as sites for recreation (Arnberger et al., 2018). However, where ecological deterioration occurs without visible damage, such as when a non-native ecosystem displaces a native one, visitor perceptions of the area can vary depending on their knowledge of local ecology (Barendse et al., 2016; Bravo-Vargas et al., 2019).

NATURAL AREAS OFFER VIEWS AND AND EXPERIENCES WITH UNIQUE NATURAL FEATURES

Natural areas provide visitors with views and experiences with unique natural features, such as bodies of water and geological formations. Unique natural features can foster a sense of place, which in turn provides diverse benefits to health and well-being, including recovery from stress and lower risk of mental illness (Hausmann et al., 2016).

In a systematic review, Gascon et al. (2017) found consistent evidence that exposure to blue space (including lakes, coastlines, rivers, and other bodies of water) is associated with improved mental health and increased physical activity. Some studies also suggested correlations between blue space exposure and cardiovascular health, general health, and obesity rates, but these results were not consistently demonstrated across publications (Gascon et al., 2017). While most studies within this review largely used remote sensing to correlate health outcomes with the amount of blue space near one's home (Gascon et al., 2017), several demonstrated health benefits from spending time recreating near blue spaces (e.g., Amoly et al., 2014; Elliott et al., 2015; MacKerron and Mourato, 2013).

California newt. (photo by Ron Wolf, courtesy of Midpeninsula Regional Open Space District and CC BY 2.0) District)



Recreation opportunities in natural areas are linked to their own set of benefits

Each type of recreational activity is associated with its own suite of health outcomes. Our understanding of these health outcomes is limited by the popularity of each recreation type as a focus of study, and the most commonly studied activity is hiking (Thomsen et al., 2018).

BENEFITS OF HIKING AND RECREATIONAL WALKING

In the wildland recreation and health literature, the most commonly studied activity is hiking, possibly due to its popularity (Thomsen et al., 2018). Many studies have also found significant mental health benefits of hiking or walking in nature. Hiking is associated with benefits such as improved self-esteem, reduced diabetes risk, connectedness to nature, and physical fitness (Barton et al., 2016; Freidt et al., 2010). Relative to walking in an urban environment, walking in nature is linked with reduced symptoms of depression (Bratman et al., 2015), lower heart rate and anxiety levels (Song et al., 2014), and better cardiac function among coronary artery disease patients (Grazuleviciene et al., 2015). These studies indicate that for the same activity, a natural venue enhances the health outcome.

Dog-walking is a popular activity on Midpen lands. Dog ownership has an important influence on whether a person gets regular exercise, and access to public open space is positively associated with dog walking (Westgarth et al., 2014). Dog walking can help people increase physical activity levels, and the proximity of parks influences an owner's dog walking behavior (Christian et al., 2016). Through interviews with dog owners who have long-term health conditions (e.g., multiple sclerosis, diabetes, asthma, stroke), one study in New Zealand found that dog walking can alleviate feelings of social isolation and enhance well-being by relieving stress and requiring adequate exercise (Smith et al., 2017).

BENEFITS OF OBSERVING WILDLIFE

Relatively few studies have quantified the health benefits of observing wildlife in natural settings, but the existing literature highlights the potential psychological benefits of human-wildlife encounters. Cobar et al. (2017) assessed the mental health impacts of bird-watching among high school students and found that, compared to those students who took walks without observing birds, students who engaged in bird-watching experienced significantly more reductions in tension, fatigue, and confusion. Curtin (2009) documented feelings of awe, wonder, and well-being among tourists on wildlife tours in Spain and California. Follow-up surveys revealed that such feelings are not necessarily limited to experiences with charismatic megafauna in exotic locations, but can also occur when visitors encounter local wildlife near their homes (Curtin, 2009). The value that people derive from encounters with wildlife depends on a variety of personal factors, particularly their perceptions of and past experiences with the species they encounter. People with greater familiarity with animal diversity may be poised to garner greater benefits from wildlife encounters (Bell et al., 2018). When people perceive animals as a threat to their health or safety, they are unlikely to derive mental health benefits from viewing them (Barua et al., 2013; Soulsbury and White, 2016).

BENEFITS OF MOUNTAIN BIKING

There is a lack of data on the health impacts of mountain biking; in the wildland recreation and health literature, only six papers studied mountain biking (Thomsen et al., 2018). However, Dillard (2017) contends that mountain biking is as healthful an activity as road cycling, for which there is vastly more evidence available. The health benefits of road cycling include cardiorespiratory fitness, lower risk of heart disease, lower risk of stroke, improved muscular fitness, and reduced depression (Oja et al., 2011).

Some studies explored the perceived benefits of mountain biking using survey methods. Mountain bikers engage in the activity for a variety of reasons, including the perception that mountain biking makes them feel more connected to nature (Roberts et al., 2018). The feeling of connection with nature is thought to be of great benefit to human well-being (Mayer and Frantz, 2004; Shanahan et al., 2016a). Other motivations for mountain bikers included the beliefs that the activity helps them to de-stress, improves their self-esteem and helps them deal with negative thoughts or feelings (Roberts et al., 2018). Another study found that some benefits varied by gender; women perceived mental health benefits of mountain biking (e.g., self-reliance, self-esteem, life satisfaction) more strongly than men (Hill and Gómez, 2020).

In recent years, electric pedal-assist bikes (e-bikes) have emerged, and may make it more feasible for some to engage in biking activities (Hall et al., 2019). Following suit, new research is emerging to understand the health benefit from e-bike use, but current studies are very few in number. In the case of electric pedal-assist mountain bikes (eMTB) specifically, the literature is extremely limited. One study found that eMTB use helps individuals meet physical activity guidelines and supports cardiovascular fitness nearly as much as conventional mountain bike use (Hall et al., 2019).



Mountain biking in the forest. (photo by TJ N, courtesy of Midpeninsula Regional Open Space District and CC BY 2.0)

BENEFITS OF ORGANIZED ACTIVITIES

Midpen hosts a wide variety of docent-led activities year-round, including guided hikes, educational programs, and equestrian activities. Midpen also partners with schools and various community groups such as Latino Outdoors to provide guided nature experiences for diverse youth, and conservation groups such as the Sierra Club hold outings for their members in Midpen preserves. As most wildland recreationists travel in social groups, the social aspect of wildland recreation is a key driver of positive health outcomes (Thomsen et al., 2018; Holland et al., 2018). Studies have found that organized activities in the outdoors is important for both children and adults. Among children, access to recreational programs can significantly promote physical activity and lower the risk of being overweight (Wolch et al., 2011). Beyond mental and physical health, the social aspects of wildland recreation also contribute to pro-social behaviors, sense of place, environmental stewardship, and even academic performance (Holland et al., 2018).

Some researchers are beginning to evaluate the potential role of new nature-based therapeutic programs in managing and supporting recovery from mental illness. In the U.K., a nature-based program consisting of weekly countryside and urban park walks resulted in significantly greater self-esteem and mood improvements than other existing programs (Barton et al., 2012). Also in the U.K., a novel 6-week treatment based on visits to a wetland reserve was found to be an effective therapy option for anxiety and/or depression (Maund et al., 2019). The visits included guided walks, watching wildlife and canoeing. Such novel treatment programs are nascent, yet there is growing evidence for the benefits of including nature-based treatment in the management of and recovery from mental illness.

BENEFITS OF OTHER ACTIVITIES

In the wildland recreation and health literature, there are very few studies related to other activities available on Midpen lands. On Midpen lands, one campsite is provided at Monte Bello Open Space Preserve, and in the limited number of studies relating to backpacking and camping, there is evidence of these activities' positive contributions to self-esteem (e.g., Autry, 2001; Kiernan et al., 2004). 21 of Midpen's preserves are open to horseback riding, providing approximately 215 miles of trail. There are very few studies available that examine horseback riding and health outcomes, and most of these studies focus on therapeutic horseback riding as opposed to recreational. A study conducted in Austria found that recreational horseback riding is associated with a greater sense of nature relatedness, greater overall well-being, and better mood (Schwarz Müller-Erber et al., 2020). As research continues to emerge, there may be more to learn about the potential health benefits of these activities.

Broader implications for public support for conservation

While experiences in nature can significantly support human health, they can also play a critical role in sustaining public support for biodiversity conservation. Feelings of connection with nature can lead to pro-environmental behavior (Mackay and Schmitt, 2019). A primary way that both children and adults develop feelings of connection to nature is having direct experiences with nature (Cleary et al., 2020). For children, having an adult role model whom the child perceives to be knowledgeable about the environment and active in trying to maintain environmental quality is another way to foster nature connection (Chawla, 2015; Sivek, 2002).

In adulthood, direct recreational experiences with nature can have a significant impact on public support for conservation. Some characteristics of wildland recreation that influence the outcome of environmental stewardship include examining the natural environment, wilderness as a source of adversity, social interactions, trip leader's interpretation amount and quality, and duration of experience (Holland et al., 2018). Overall, outdoor recreationists — especially those participating in wildlife watching and nature photography — have been found to have higher levels of environmental concern than non-recreationists (Teisl and O'Brien, 2003), and 4-5 times more likely to engage in conservation behaviors like participating in local environmental groups and enhancing wildlife habitat on public lands (Cooper et al., 2015).

Nature experiences also significantly impact willingness to financially support conservation. Bird-watchers are more likely than non-recreationists to donate to local conservation efforts (Cooper et al., 2015). A study in the U.S. found that each hiker or backpacker may contribute \$200–\$300 annually in the future to conservation NGOs (Zaradic et al., 2009). On a related note, San Mateo County Parks conducted a study to determine willingness to pay through taxes or fees for parks, trails and other amenities at the parks (San Mateo County Parks Department, 2016), an approach which Midpen could also adapt and implement to better understand the connection between nature experiences in Midpen's preserves and willingness to pay for continued conservation efforts. Efforts to educate the public can also be influential, as Buttke et al. (2014) suggested that having an increased understanding of biodiversity's value and benefits to human health and well-being may lead to greater support for conservation. Overall, these studies indicate that encouraging participation in hiking, backpacking, bird-watching, and nature photography should be considered in strategies to secure long-term support for conservation.



Great egrets. (photo by Axel Sudhausen, courtesy of Midpeninsula Regional Open Space District and CC BY 2.0)

Conclusion

A large body of literature on the connections between nature and health illuminates the great diversity of physical, mental, and social benefits derived from nature exposure, including improved cardiovascular health, lower risk of depression, recovery from stress, social cohesion, and much more. These studies have also explored and shed light on moderating factors, which influence the extent of benefit received by an individual, such as accessibility and other characteristics of open space.

In the literature specifically on wildland recreation, each type of recreational activity is associated with its own suite of benefits, and certain characteristics and qualities (e.g., duration of experience, level of challenge) are factors that influence the benefit of the activity. The activities offered in Midpen's preserves are linked with numerous benefits to physical, mental, and social health. Activities within preserves are not without their tradeoffs, which will be explored in the next phase of this project.

In addition to studies specific to wildland recreation and health, land managers can draw from the broader and vastly more plentiful nature-health literature. These studies enable land managers, planners and policymakers to make informed, science-driven decisions about what types of activities to allow and experiences to curate on public lands, not only for health and well-being, but also for fostering and sustaining public support for conservation. Some comparative studies provide evidence to suggest stronger results from certain activities, such as hiking, backpacking, bird watching, and experiences with high quality trip leaders. As research specific to wildland recreation and health continues, findings may emerge that are directly relevant to management and planning future uses on Midpen lands. An adaptive and science-based management approach is recommended as more research becomes available.

PRELIMINARY RECOMMENDATIONS:

- There is a limited amount of available research on certain types of recreational activities. Midpen staff can monitor research as it emerges to deepen their understanding of the health outcomes of horseback riding e-mountain bike use in particular.
- Offer organized group activities that foster a sense of community and support physical and mental health.
- Spending time in nature is linked with public support for conservation. Emphasize bird-watching and nature photography, as these activities in particular are linked with elevated pro-environmental behaviors like participation in environmental stewardship and donating to local conservation efforts.
- Midpen is a major regional resource offering substantial health benefits, but the accessibility of some of its preserves may leave some people out. Midpen may pursue a better understanding of the scientific literature on equity in nature access and develop best practices for engaging certain underserved communities as part of Midpen's diversity, equity, and inclusion efforts.

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